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THE Association was organized in Boston, Mass., on June 21, 1882, with the object of providing its members with means of social intercourse and for the exchange of knowledge pertaining to the construction and management of water works. From an original membership of only TWENTY-SEVEN, its growth has prospered until now it includes the names of 900 men. Its membership is divided into six classes, viz.:

A Member shall be an officer or employee of a public or private water works, an engineer, chemist or other person qualified to aid or interested in the advancement of knowledge relative to water works.

An Honorary Member shall be a person of acknowledged eminence in some branch of water supply or of engineering.

A Junior shall be not less than eighteen years nor more than twenty-five years of age, a student or connected with water supply work.

An Associate shall be either a person, firm or corporation engaged in manufacturing or furnishing materials or supplies for the construction or maintenance of water works.

A Corporate Member shall be either a Water Board, Commission, Company or Municipal Corporation.

The initiation fees and annual dues are as follows:

	Initiation Fees		*Annual Dues*
Members	$ 2.00	Members	$ 6.00
Juniors	1.00	Juniors	3.00
Associates	10.00	Associates	25.00
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This Association has at least eight regular meetings each year, of which five are held in Boston, one in northern New England, one in southern New England, and one, the annual convention, held in September on such date as the Executive Committee may designate.

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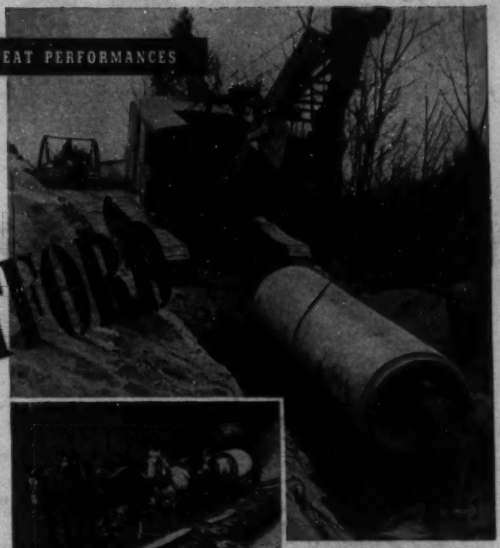

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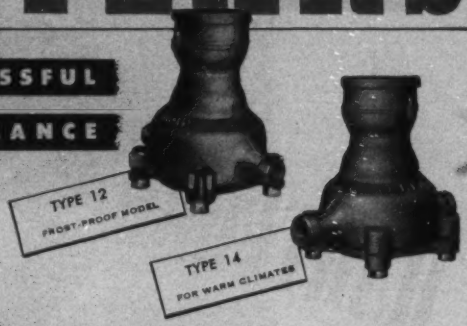

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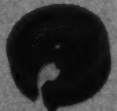

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Engineering Facts about

Johns-Manville TRANSITE PRESSURE PIPE

*Winnipeg: A case history**

IN 1932, Winnipeg, Manitoba, installed its first Transite Pressure Pipe. Part of this installation, consisting of an 18" line, was recently tested in field and laboratory to determine its condition after 14 years of service in an extremely corrosive soil.

Pitometer Flow Test

Before the pipe was removed for laboratory tests, its flow capacity was checked by the Pitometer Company. Velocities ranged from 1.1 to 1.9 feet per second and readings were taken at 30-second intervals. During each test, the velocity was held constant. Results were summarized by the Pitometer Company as follows:

Assembly of pipe and coupling being removed from the line for laboratory tests.

"The high value of C-140, which we believe is a reliable index of the present capacity of the pipe tested, shows that there has been little if any loss in capacity since 1932 when the pipe was laid."

Soil Conditions

This Transite Pipe was laid in soil known to be destructive to water pipe. Analysis showed the presence of certain soluble salts, which, when dissolved by ground water, became highly corrosive.

Readings being recorded during Pitometer flow tests on the line.

To determine how well the pipe had withstood these corrosive conditions and to estimate its life expectancy, sections of the pipe were removed from the line and subjected to a series of physical tests.

The most significant of these tests were the hydrostatic pressure tests.

Hydrostatic Pressure Tests

To simulate field conditions as closely as possible, an assembly consisting of portions of two lengths of pipe joined by a Simplex Coupling with rubber rings and sleeve intact was tested hydrostatically. Water pressure was raised to 260 psi—the original test pressure to which this pipe was subjected at the factory and 4 times the normal working pressure of the line. The pressure was held at 260 pounds while observers carefully examined the coupling for leakage. No leakage occurred. The rubber rings functioned as well as when the pipe was placed in service 14 years previously. Subsequent inspection and tests confirmed that they were free from any signs of deterioration.

The pipe and coupling undergoing pressure test.

Specimens of the Winnipeg pipe were also subjected to other laboratory tests. Crushing tests showed that the strength of this 14-year pipe compared favorably with that of new Transite Pressure Pipe manufactured today. A corporation stop pull-out test provided further verification that the strength of this pipe was in no way impaired.

Summary

The series of tests outlined above provided conclusive evidence that the strength, flow capacity and other physical characteristics of the Winnipeg pipe were unimpaired after 14 years' service under severe conditions. As the original report states, they demonstrated that "on the basis of the performance rendered to date, it is reasonable to anticipate a life-expectancy of many times that already obtained."

**A copy of the detailed performance report on this Transite Pipe installation is available on request. Address Johns-Manville, Box 290, N.Y. 16, N.Y.*

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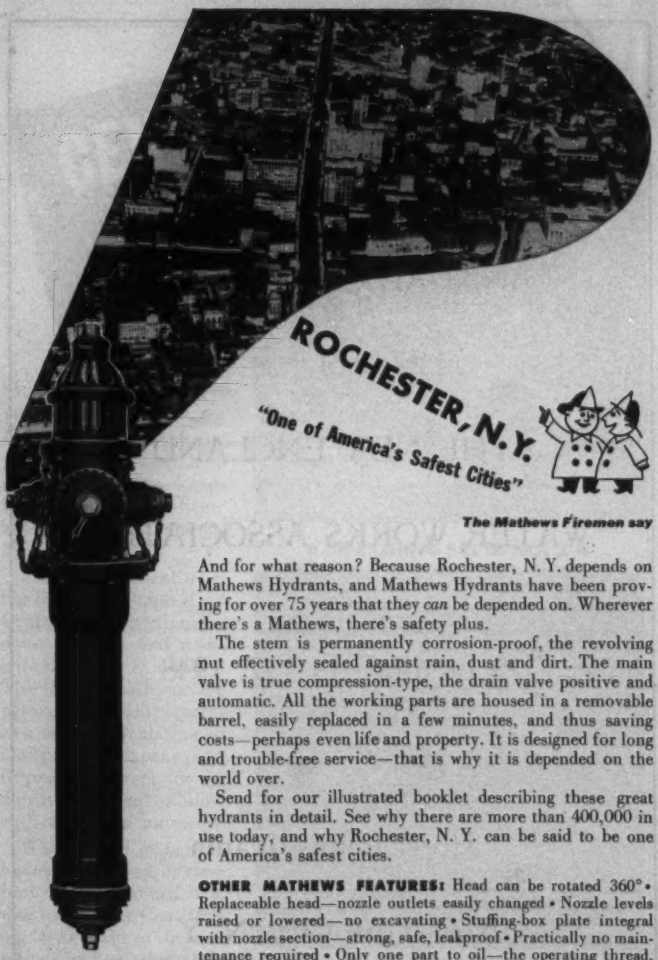

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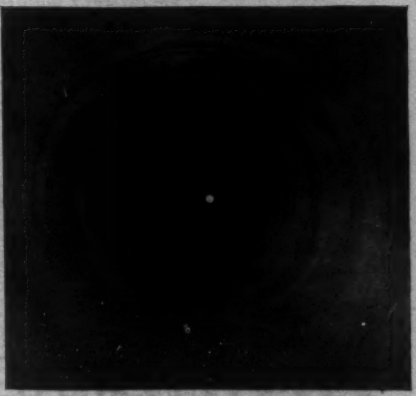
▶ PIPE LINING FACTS NO. 2 ◀



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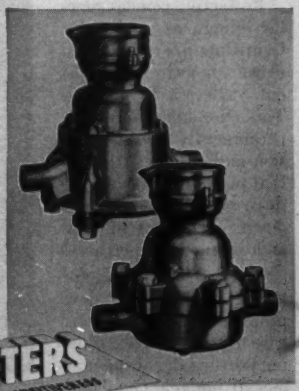

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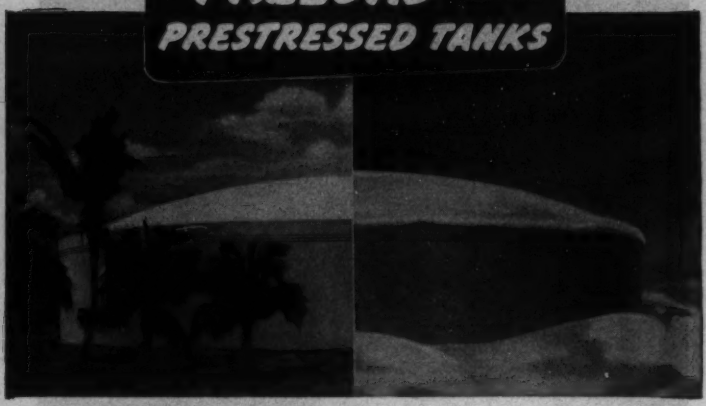

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Table of Contents

PAGE

Emergency Water Supply for Rutland, Vermont, Following Flood of June 3, 1947
By Edward L. Tracy 103

Selling Your Water Works
By George N. Watson 117

Distribution-Pipe Problems
By Kenneth W. Robie 122

Recent Developments in the Chemical Treatment of Water Supplies
By Lazarus Rubin 126

Work of the New England Forestry Foundation on Watersheds
By Harris A. Reynolds 133

Small Ground-Water Supply Systems for State Parks
By Arnold E. Howard 141

Reflections on the Bar Harbor Fire
By Theodore W. Grindle 154

Forest-Fire Hazards
By Raymond E. Rendall 160

Experiences during the Recent Fires in York County, Maine
By Leander G. Smith 164

A Preliminary Report on Sanitary Engineering Aspects of National Security
By the Subcommittee on Sanitary Engineering Aspects of Major Catastrophes, National Research Council 169

Proceedings:

February 1948 Meeting 187

March 1948 Meeting 190

Tentative Standard Specifications for Reinforced Concrete Water Pipe —Steel Cylinder Type, Not Prestressed .....Appended

New England Water Works Association
ORGANIZED 1882

VOL. LXII JUNE, 1948 NO. 2

This Association, as a body, is not responsible for the statements or opinions of any of its members

EMERGENCY WATER SUPPLY FOR RUTLAND, VERMONT, FOLLOWING FLOOD OF JUNE 3, 1947

BY EDWARD L. TRACY*

[Read September 18, 1947.]

THE Rutland flood of June 3, 1947, was the most disastrous to a water system and created the greatest problem of emergency water supply that ever occurred in Vermont. The water stored behind East Pittsford Dam on East Creek, about six miles northeast of the city, burst through the dam and flooded the western area of the city, forcing the evacuation of about 500 families. Water supply, gas and electricity were cut off and total damage may be $8,000,000.

Rutland, with a population of 18,000, is in the west central part of Vermont, on the east side of Otter Creek, one of the main streams of the Lake Champlain - St. Lawrence drainage basin. This river flows north, but the area east and northeast of the city drains southwesterly down East Creek. This stream joins Otter Creek on the west side of the city. On East Creek, northeast of the city, there are three power dams. The upper one, Chittenden Dam, 12 miles northeast of Rutland, holds back about 6,000 mil gal of water. Downstream six miles, East Pittsford Pond was much smaller, holding about 1,500 mil gal. About two miles farther downstream is Glen Dam, a small pond. Just above Glen and a very short distance from the east side of East Creek, the city water-supply reservoirs, the intake from Mendon Brook, and the chlorinator and meter house are located. Two parallel pipe lines, 12 in. and 16 in. in diameter, bring water four miles into the city. The city uses more than 3 mgd—a high consumption rate, but one which is easily supplied by the 24-sq mi watershed. Because of the reliable flow from this large forested watershed, the 5-mil gal main water-supply reservoir was considered adequate by most people.

*Director, Division of Sanitary Engineering, Vermont Department of Public Health, 2 Colchester Ave., Burlington, Vt.

Many of you engineers and water-works officials have seen much larger floods of longer duration, so I will not spend much time in description of the flood causes. There had been above-normal rainfall and all storage ponds on East Creek were full and discharging a heavy overflow. During the morning of June 3, part or all of the flash-boards on Chittenden Dam went out, letting the top level (probably three feet) discharge down East Creek. This caused high water, but not enough to call a flood, in the city. It did very serious damage in the small community of Chittenden. It also topped all or part of East Pittsford Dam and a little after 8 p.m. (after the high water of the afternoon had subsided in the city and the people felt reassured) the dam gave way.

The effect is probably best described by a quotation from the Rutland *Herald* of June 5, as follows: "It was at exactly 8:05 P.M. Tuesday night that the Central Vermont Public Service Corp., warned two minutes earlier by a frightened East Pittsford man 'that the dam was going out', notified Major Wayne N. Temple that the city lay in grave danger. Immediately the National Guard was mobilized and the police department began evacuating people in the northwest area of the city. The pent-up force of thousands of tons of rampaging water gathered momentum as it raced six miles into Rutland and literally gutted the west end of the city. The flood, headed by 'a 15-foot mass of water', crossed U.S. Route 7 in Mill Village and headed into Rutland even as hundreds were leaving their homes.

"Men sprung up from the streets to defend Rutland in its bad hour and their earnest and many times heroic work did much to save lives in a battle against a savage foe.

"As the water rose up along Cleveland, Baxter and Pine Streets, men pitted their lives against the flood tide and came out the victors. Policemen, who fought successfully to save three men marooned in one spot, found themselves a few seconds later being rescued by some of their comrades.

"Firemen, many of whose homes were being battered by the ugly brown waters, stood by their posts and guided fellow citizens to safety. Public works employees kept up a continual battle against the foe.

"At the city hall, civic officers directed their forces with speed and calm.

"By 11 P.M. the flood tide was receding. In a sense the crisis was over. In another, it had only begun.

"Yesterday morning, after an early fog had cleared, the sun shone down on a scene of utter destruction. In an area taking in 20 streets, residents came back to find their homes submerged in a sea of thick muck."

The city was without water, gas and electricity. The Rutland *Herald* could not publish an issue on the morning of June 4. G. E. McLaughlin, managing editor of the Rutland *Herald*, wrote for the Associated Press: "It's pretty hard to sit in an office chair and watch your city's biggest story come into town in the other fellow's newspaper. People who rely on the *Herald* for their morning news, in this small area we serve, are crowding in front of our bulletin windows, hardly believing that a flood or lack of electricity could keep this 153-year-old paper from publishing."

That there was no loss of life and, later, that there was no disease can only be called a miracle.

After East Pittsford Dam failed, the pond behind Glen Dam filled up with gravel and silt and diverted the flood flow of East Creek, so that it ran back and forth across the two water-supply pipes a short distance below the water-supply reservoir. This uncontrolled stream washed out 600 ft of 16-in. pipe and 900 ft of 12-in. pipe in three sections and badly clogged the pipe sections that remained in place between the breaks. The main reservoir, the intake, and the chlorinator and meter house were not damaged, but two small auxiliary reservoirs were completely destroyed.

The first call to the State Public Health Department in Burlington came from the Rutland City Engineer a little after 9 p.m., June 3. I was stranded in St. Johnsbury, in the northeastern part of the state, by high water and damaged highways, but fortunately Dr. Robert B. Aiken, Executive Secretary of the State Board of Health, was in Burlington [he had been unable, because of high water, to reach St. Johnsbury on June 3] and received the report of the Rutland flood and the City Engineer's request for an emergency chlorinator. He reached me by telephone about 11 p.m. and I re-

quested him to send Robert L. Hood, of the Sanitary Engineering Division, to Rutland with a chlorinator and a supply of calcium hypochlorite.

Both Mr. Hood and Dr. Aiken reached Rutland in the morning, June 4. The water-distribution system was practically empty, no water was coming into the system and there was no auxiliary source of supply connected with the system. Not only was there no domestic water supply, there was no fire protection. An Emergency Water Committee, headed by Alderman Joseph Abel, was formed and plans were quickly made to supply drinking water and water for sanitary use.

New, clean fuel-oil tanks were mounted on trucks and milk trucks were put into service to deliver water to drinking-water depots at all school buildings, many gas stations and other convenient points, where people could get it in their own containers. The water was obtained from three safe wells and springs south of the city. The city Health Officer, Dr. Charles D. Beale, issued an order by radio and printed hand-bills to boil all water before drinking, as a precautionary measure. Routes were organized for trucks to deliver water from house to house for sanitary use.

I arrived in Rutland early in the afternoon of Wednesday, June 4, the first day after the flood. The river near the water reservoir was still too high to permit any immediate action to plan the restoration of the damaged pipes. Fire trucks had started pumping from brooks in the city into the distribution system, to supply water for sanitary use and fire protection. Fortunately, a fire in the business section of the city that afternoon was extinguished by water from booster tanks on fire trucks. Leakage from the distribution system in the flood area was stopped as fast as the leaks could be found.

Calcium hypochlorite was distributed to the drinking-water depots and Boy Scouts in charge of these stations were instructed in its use. This insured the safety of the drinking water being dispensed.

Fire trucks pumping water into the distribution system were replaced by O.C.D. pumps, as fast as enough could be brought into the city, and the pumping points were increased until there was a total of ten. The distribution system was filled and pressure was

built up. By Friday, June 6, it was no longer necessary to distribute water for sanitary use by tank truck.

On Thursday, June 5, an army-type water purifier was set up at an ice pond in the south end of the city. Drinking water was then obtained from this source instead of the springs and wells. The purifier, with a diatomaceous filter and a W. & T. hypochlorinator, was powered by a gasoline motor. It delivered water with a chlorine residual of 0.2 ppm. Many people went to unauthorized springs outside the city to obtain drinking water, but the practice was discouraged by the city Health Officer, who announced that one spring, which was being heavily patronized, was contaminated. It seems to be a firm opinion of too many people that clean-appearing spring water in rural locations is always free from contamination. This is an unfortunate opinion that is difficult to overcome.

Aid came quickly and from many places to Rutland. Firemen, fire trucks and O.C.D. trailer pumps were sent by several Vermont and Massachusetts communities and by the Army. Chlorinators and calcium hypochlorite, as well as men and repair materials, were sent by Burlington, Brattleboro and Windsor. Joseph Moore, Justin Holden and Vail Leach, water superintendents at these places and all members of the New England Water Works Association, reached Rutland Wednesday and offered their assistance. Wallace & Tiernan Co., Inc., and Proportioneers, Inc., reached me by telephone Wednesday with offers of help. The Sanitary Engineering Division of the Public Health Dept., understaffed for even normal work, is greatly indebted to Wallace & Tiernan Co., Inc., and the U.S. Public Health Service for furnishing engineers. The engineers of the Rutland city staff all had more than they could take care of without giving much attention to water sterilization. L. J. Peck from Albany, N. Y., and Allen Johnstone from Connecticut, Wallace & Tiernan men, and Mr. Udell of the New York office of the U.S. Public Health Service arrived soon after the flood, to assist in the work of chlorinating the distribution system and restoring normal water supply and chlorination. A trailer-mounted emergency chlorinator was brought in from Newark by Wallace & Tiernan, because it was not known at first whether the city's regular chlorinator would function.

Governor Ernest Gibson surveyed the flood area by plane and

conferred with city officials the day after the flood. A request for aid was sent to the Army and on Thursday members of the First Army Staff from New York arrived.

On Friday, June 6, water-purifying equipment and Army engineers arrived in two large transport planes from Fort Belvoir. The planes landed in the afternoon and by evening two large water-purifying stations, one on Tenney Brook in the north end of the city and one on Moon Brook in the south end of the city, beside highway U.S. 7, were producing filtered, chlorinated water with a residual of 0.2 ppm. From then on, all drinking water came from these sources. Army water cans replaced the tanks and milk trucks at drinking-water depots.

Although the city Health Officer issued daily warnings against using water from the distribution system for anything but sanitary use, we considered it a hazard, because of the possibility that children or uninformed persons might drink the water. The surprising clearness of the water added to the hazard. By Friday, after the purity of water at the drinking-water depots had been well established, we surveyed the pumping stations supplying water to the distribution system. Seven were on Tenney Brook in the north and northwest part of the city and three were on Moon Brook in the south end of the city. Because of the number of pumping points, it was decided that it would be practically impossible to chlorinate the entire distribution system with a mobile chlorinator. Hypochlorinators which were available would have provided good chlorination, but it would require too much time to cut in electric connections. Mr. Peck and I decided to use chlorine solution in barrels at all pumping points and apply it through hose into the suction strainer of the pumps. New steel barrels, the only kind that could be found, were each fitted with a ⅛-in. valve, placed 6 in. above the bottom of the barrel, so that hypochlorite powder would not clog the valve. These valves were ordinary brass valves, such as are used with gasoline tubing in automobiles. Each was inserted through a hole drilled in the barrel and was held by a flat gasket and a lock-nut. Windshield-wiper rubber hose was cut the proper length to reach from wherever the barrel was placed at each station to the pump suction-hose. With most of the pumps located near bridges, it wasn't easy to place some of these barrels.

At first a 0.5% chlorine solution was used, but this was too corrosive, so it was cut to 0.25%. The valve was set to deliver enough chlorine to give a residual of 1 to 2 ppm on the pressure side of the pump. The firemen tending the pumps were trained to mix the chlorine solution. Calcium hypochlorite and water were added, when the barrel contents drew down about one-third, a relatively uniform head of chlorine solution being thus maintained. This chlorination method was pretty crude and, of course, the valves plugged sometimes, but it was surprising how soon a chlorine residual of 0.3 to 2 ppm was built up throughout the distribution system and how well it was maintained.

On Thursday, the second day after the flood, a typhoid-inoculation station was set up in a school building by the State Public Health Dept. and local doctors. About 3,500 people, largely from the flood area or working there after the flood, were inoculated for typhoid fever.

The work of restoring the damaged water-supply mains was started as soon as men could reach the location on Thursday. Getting in was difficult, because the entire vicinity was a wild jumble of boulders, trees and debris. Before East Creek could be put back in its proper course, it was necessary to dig a channel through the gravel and silt that had filled the pond above Glen Dam. On Friday, the Warren Foundry and Pipe Corp. trucked in the 16-in. pipe needed. By the following Monday this was all in place, except the last length at the lowest break, but the dirt and stones in the sections of the pipe that had remained in place could not be washed out by reservoir pressure or by crawler nozzles operated by water from O.C.D. pumps. The National Water Main Cleaning Co. was called in and, after very difficult work and hard luck, such as burst sections of pipe from the pressure developed in the cleaning process, the restoration of the 16-in. main was completed June 18. At least part of the worry about fire protection was over, but the 16-in. pipe alone would not supply the city.

On June 14, it was decided that, with the 16-in. pipe repaired, it would be best to pump into the 12-in. main at the lower end of the breaks, about ¼-mile below the reservoir. The overflow brook from the reservoir was available nearby as a source of reasonably

clean water. Pumping at this point was easier than in the city against the distribution-system pressure. During the ten-day period that the pumps had operated in the city, 22 firemen had been required to man them. The gasoline consumption at the ten pumping stations averaged 1,300 gal per day. Each 500-gal pump, powered by Ford or Chrysler engines, used about 130 gal of gasoline per day. All operated 24 hr unless required to shut down for service. It was estimated that the ten pumps were delivering between 5 and 6 mgd. This larger-than-normal quantity was required because of leakage and because many streams of water were being used for washing mud from the inside and outside of houses in the flood area.

A multiple connection for the 12-in. main was made from a piece of ½-in. sheet steel. Within the area of the inside circumference of the 12-in. bell, there was room for seven hydrant nipples, spaced so that hose couplings would have room to turn. Seven round holes were cut in the plate and hydrant nipples welded into the holes. The connection was clamped to the bell of the 12-in. pipe. A rubber gasket made the connection reasonably tight.

During times of peak water consumption, the 16-in. main and four pumps, with a total of seven hose lines to the 12-in. main, provided ample water and pressure. The water in the 16-in. main was chlorinated by the Wallace & Tiernan MASV chlorinator in the building just below the reservoir. The water pumped into the 12-in. main was chlorinated by direct feed from a tank of chlorine gas to the suction hose of one of the pumps. A manual-control chlorinator could have been used here. The results of the direct feed were so satisfactory during the intermittent periods of pumping that no change was made.

The chlorine residual maintained in the distribution system was between 0.5 and 2 ppm.

Repairs to the 12-in. main were made as quickly as possible with the same difficulties that the 16-in. had given. Plugs of dirt and stones were removed from the sections of pipe that had remained in place in the flood stream area. The work was completed and the main put into normal service on June 27. Not until then did the Army water-purifying plant in the city dismantle all equipment and leave Rutland.

During all this period water samples were taken daily from five points in the city, one from the center and one each from the north, south, east and west sides. Contamination was excessive until June 8, as should be expected, because water was pumped from brooks into the distribution system without chlorine for two days. The last excessive contamination anywhere in the distribution system was found on June 12. From June 6 to 12, 40 10-ml portions of water were analyzed and 15, or 37½%, contained coliform organisms. From June 13 to 29, only 15 of 415 10-ml portions of water, or 3.6%, contained coliform organisms. After June 29 normal water sampling, one specimen each day, was resumed. Almost countless tests for chlorine residual had been made throughout the distribution system during the three weeks following the flood.

The State Department of Public Health notified the Mayor and Health Officer on June 25 that all restrictions and warnings against use of water from the distribution system for drinking could be withdrawn. There had been no contaminated samples during the four previous days. As far as quality was concerned, the system was entirely back to normal.

The Rutland flood demonstrated very forcibly a number of fundamental water-system requirements or needs, of which we are all aware but for which many times we do not properly provide. In order to be considered complete, a water-supply system should have one or more auxiliary sources that are as widely separated as possible. There should be some storage, at least in distribution reservoirs, in or very near the community, to meet fire-protection and minimum domestic needs, when the main source of supply goes out of service. In Vermont, practically all communities are too widely separated to have connections between two municipal water-supply systems.

An efficient and not too complicated plan for mutual aid between cities should be kept active. Such plans were worked out before and during the war, but it is likely that many communities have not kept them up to date.

The Rutland flood prompted the First Army to work out a plan for disaster relief that will serve as a guide for the future. Besides the flood that I have described, a much greater danger threatened Rutland for about eight days after June 3. This is best described

by the following First Army release, which appeared in the Rutland *Herald* two weeks after the flood: "The jealously-guarded secret of why the United States Army moved into Rutland—above and beyond the work of purifying and distributing drinking water—was revealed in an official First Army release describing its plans for evacuation and care of the city had the Chittenden Dam collapsed. The release was made coincident with the return to Governor's Island, N. Y., of a majority of Army officer personnel stationed here since shortly after the June 3 flood, and with the passage of any further danger from the giant reservoir in the hills 12 miles northeast of the city.

"This master plan, ready to be put into action the moment the dam broke, included evacuation, rescue and relief of flood victims, traffic control, medical service, air service, military police, sanitation and the supply of essential food, clothing and shelter.

" 'Fortunately it was not necessary to put this plan into effect', said Colonel G. A. Williams, 'but it will be retained by First Army headquarters as a guide in case a similar disaster overtakes any other community in the First Army area'."

Discussion

Warren J. Scott (Hartford, Conn.). What was the capacity of these Army filter units, approximately?

Edward L. Tracy. That I don't know, I am sorry to say. I don't know what their producing capacity was. I was like the city engineers; I had too much to do. Each one consisted of an 8-ft fabric tank set up with poles. Those were of the conventional size—that is, about 15 to 18 ft in diameter. They used one for coagulation and they gave us all the others for finished-water storage. They had at least 12 to 14 of those tanks full of water. There were more than they needed. The second purifying plant did not remain set up as long as the first one did; they did not need the water.

Arthur L. Shaw (Boston, Mass.). Do you know, Mr. Tracy, whether there has been any fire of any seriousness in Rutland since the pipe lines were replaced?

Mr. Tracy. No, there has not been any fire.

Mr. Shaw. What I have in mind is the possibility of some difficulty because of fist-size and smaller stones and pebbles, which

might have been washed down into the undamaged parts of the pipe and might lodge there until some fire occurs, when they would be swept into the hydrant barrel and either lodge in the gates or damage the gates, hydrants or hose lines into which they were carried.

MR. TRACY. They have been blowing the lines as much as they could intermittently since and have not found any stones yet. There is some sand which has come down as far as the city. Of course there is a possibility, because right in the area of the break there were stones up to 12 in. in diameter. So that there is the possibility that stones might be carried down into the distribution system. There is no question but what the water-supply system was in very bad shape after the flood. Even when the two pipes were restored, it still was not too good, because the consumption rate was up. Of course the rate was very high, but nobody would dare to tell these people in the flood area that they could not wash off or wash out their houses, so that the rate of consumption of water stayed very high for a long time; in fact, it is still much higher than normal. But I am glad to say that just this week the City Council has decided to have a complete survey made of the water system with recommendations for improvement. Of course we hope it will be entirely rebuilt.

THEODORE L. BRISTOL (Ansonia, Conn.). How were the people fed?

MR. TRACY. The Red Cross did a very good job. I did not refer to that in the paper. The Red Cross set up canteens very quickly. The people who were evacuated from some of these houses were brought to the Armory, which is on high ground. The Red Cross immediately began taking care of them the night of the flood. They maintained a canteen downtown in the central fire station. Apparently they had an endless supply of food, because anybody that wanted to could and did eat there. Then they operated mobile canteens throughout the flood area. That is, trucks would go around the city and bring meals right into the homes of the people. Nobody was without food.

A MEMBER. Was the cause of the dam failure determined?

MR. TRACY. I would not dare to answer that, because that dam failure is the basis of a number of suits, some of which have been filed in the county court and some in the federal court. It will be

a very interesting situation to watch. The city has filed suit for $1,250,000 and many property owners have also filed suits for damages to their private property. The people who are bringing suit allege improper operation of the dam. Of course we know that the power company will have a defense. I only briefly mention the fact that the top three or four feet of water from the upper dam, which was the largest one, came through in the morning, which caused high water all day at the second dam, which had a smaller pond, and water flowed over that embankment, I believe, all day, or from the morning until it went out that night. But I would not dare to say any more than that.

THE MEMBER. A concrete core wall?

MR. TRACY. Concrete core wall and earth fill.

LINN H. ENSLOW (New York, N. Y.). Do I understand correctly that the storage was in the dam 12 miles out—that they did not have any distribution?

MR. TRACY. No distribution reservoir. When the two pipe-lines were cut off, there was no water at all, except what was in the pipes. Of course that did not stay very long; that was drawn out. I don't know how many leaks there were, but of course some leaks developed in the flood area. Some hydrants were broken off by houses which floated by them, so that by morning of the next day there was no water anywhere; the distribution system was empty. That is why they started pumping into it. Of course the primary object of that pumping was to provide fire protection.

A MEMBER. Is the Chittenden Reservoir a drinking-water reservoir?

MR. TRACY. No, none of those three are drinking water—all power developments.

WILLIAM W. BRUSH (New York, N. Y.). Has Vermont had any law requiring that dams be passed upon by the Vermont state officials as to their safety in connection with floods?

MR. TRACY. Yes, that comes under the State Public Service Commission. I understand these dams were inspected and approved—I know they were in about 1940 or 1941. I don't know whether they have been since then or not. I think there was work done on the East Pittsford and Chittenden Dams after the 1927 flood.

A MEMBER. Has the state department approved the pumping of contaminated water into the distribution system?

MR. TRACY. Well, I guess the answer to that should be "No". But what are you going to do? You have an empty distribution system, no fire protection and no water for operation of sanitary fixtures. Naturally you are going to pump it in from anywhere you can find it. That is why within two days after the flood they started this heavy chlorination at the pumping stations and quickly built up that heavy residual. Of course we were trying to carry better than 0.2 ppm, but you know that you can't get it uniform, doing it in that manner.

THE MEMBER. I was wondering whether or not the hazard to health might be greater with contaminated water in the mains than the need of fire protection.

MR. TRACY. Well, in an academic discussion I would say "Yes". But put yourself in the same spot and I think you would pump water. They did not have any disease.

MR. ENSLOW. I would answer that by saying that what happened up there has proven that it cannot be too bad, with the realization that the water did not look or taste too good anyway.

MR. TRACY. Unfortunately the water looked too good. The water was extremely clear and, as soon as the distribution system was filled, when you opened a tap, the water looked as clear as normal water. It was absolutely clear water. At no time during the period of pumping—about ten days—was the water not clear, except on one occasion, when there was quite a heavy thunder shower. Then the water became somewhat turbid and at the faucet it appeared slightly cloudy. That is why we were in a hurry to get that chlorine residual built up.

MR. SCOTT. Were the brooks heavily polluted?

MR. TRACY. No, they were not heavily polluted. I don't think the coliform count would be very high, but still there was a possibility of some sewage in them.

MR. SCOTT. There were no large sewers broken?

MR. TRACY. There were no large sewers broken. At the most there would not be anything discharging into those brooks, except possibly one or two individual cases, but of course the hazard is almost as great. I think that everybody does a lot of things at a

time like that which theoretically are not correct. That is why I think it would be a good thing for communities to have a definite plan of action in the event of such a disaster. It would be rather interesting to work out beforehand what you would do, rather than work it out on the spot, because I do know that, when you are on the spot, you will pump water wherever you can.

HAROLD W. GRISWOLD (Hartford, Conn.). Would it have been possible to set up hypochlorite barrels on each brook and chlorinate all the water in the brook above your highest pumping station? Would that have meant more hypochlorite than would have been available?

MR. TRACY. I think it would have meant more hypochlorite than would have been available at first. We did not have an awful lot of hypochlorite and, the very day after the flood, we used quite a bit of it in dispensing at these water-supply depots. There were about 30 of these water-supply depots scattered around the city and, by the time we had it peddled out to everyone, there was quite a lot gone out of our small stock. We did not have enough to start with. We probably could have obtained it but I doubt if we could have obtained it quickly. But this system worked very well.

SELLING YOUR WATER WORKS

BY GEORGE N. WATSON*

[*Read at Superintendents' Round Table, Sept. 19, 1947.*]

THE subject of this paper is intriguing in the respect that many water-works superintendents seem to forget, or at least seldom realize, that it is part of their responsibility to sell the community water system to the public. Keeping the citizens of your community informed as to the difficulties you have in providing them with a constant, ample supply of safe, palatable water and as to the improvements, additions and replacements in the local water system is all part of the important job of *selling your water works.*

Prior to 1940 most municipal water departments were able to finance major improvements out of their income, but since 1940 the operating expenses of most water departments have increased approximately 50%, while the income from water rates has increased approximately 6-8%. These increased costs have materially reduced the margin that was heretofore available for needed major replacements and improvements to the water system. Thus the great importance of selling your water works is evident.

During the war years practically no replacements or extensions were made in most municipal water systems. Therefore many superintendents are now very conscious of the dire need for replacements and improvements in their water systems but, due to the lack of available funds to finance these improvements, they are reluctant to make specific recommendations as to the requirements.

A progressive superintendent will realize that it is his responsibility to make a thorough study as to the requirements of his plant and to prepare detailed plans and estimated costs of the improvements. Then, and only then, should he adopt a definite public-relations program, utilizing every possible means of selling his ideas to his public and keeping in mind that many a badly needed improvement has fallen by the wayside, because of carelessness in presenting

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the program to those having the responsibility of deciding whether the program should be initiated or shelved.

If the superintendent does a good job of selling, he will win the confidence not only of his commissioners but also of the public. This will result in easing the problem of securing approval of funds for the needed improvements.

The pros and cons as to the advisability of financing improvements by borrowing money are ever present. Due to the long life of most water-supply installations, funds may be borrowed for terms up to 25 years and usually the interest rates are very low.

A source of income that many water departments fail to capitalize on is "hydrant rental" from the town or city. It is only fair that the municipality should pay some form of hydrant rental, as it is a known fact that a large percentage of the cost of any water works is due to potential fire-flow demands for the protection of real estate. It is, of course, a grave injustice to have the water customers pay for the maintenance of a fire-protection system, which is for the benefit of all the citizens, whether or not they use a small amount or a large amount of water.

Recently the Braintree Water Department found that its water system was in dire need of extensive improvements, but the Department was not in a position to finance these improvements without some additional revenue. The Water Commissioners *sold* the water works to the citizens of the town by securing their confidence and financial support.

The Braintree Water Works, which was established in 1885, had been expanded from year to year, primary consideration being given to the needs of the town for domestic water supply. During the past 25 years, however, numerous major improvements had been made, which, while essentially for domestic purposes, had nevertheless improved materially the fire protection in some sections of the town.

A survey made about two years ago of the existing facilities of the Department revealed the following:

1. The source of supply consisted of two spring- and surface-fed ponds, having a safe yield of 3 mgd.
2. The filtration plant was designed for 2.0 mgd but could

handle 2.4 mgd for short periods. The low-lift pump was operated by a 25-hp electric motor or a 35-hp gasoline engine.

3. The pumping station contained two 2-mgd centrifugal pumps, operated by 100-hp electric motors. The reserve pump consisted of a Pratt cross-compound, Corliss valve-gear steam pump, whose capacity was 1.5 mgd.
4. The distribution system consisted of 90 miles of pipe, ranging in size from 1 in. to 12 in. Over 70 miles, or 78%, was 6 in. or smaller. Storage consisted of one 500,000-gal standpipe and one 1,000,000-gal standpipe.

The survey indicated that the source of supply was ample, the filtration plant was adequate and the centrifugal pumps at the pumping station were adequate for the present, but that the auxiliary pump was inadequate to supply the present average daily requirements, to say nothing of the maximum daily demands.

The distribution system, which had, over a period of 60 years, grown in length and extent but not in diameter, was entirely inadequate to provide the necessary (not to mention desired) fire flows. Records furnished by the Fire Underwriters Rating Association disclosed that some 48 out of 53 locations tested showed the available water supply was not adequate to meet the requirements of the Underwriters. Twenty-four of these tests showed insufficient water for two good fire streams and seven showed insufficient water for even one good stream.

The present standpipes provided sufficient storage for the Braintree and East Braintree sections of the town but did not provide for the Highlands section, which was growing rapidly.

As a result of a conference between the Water Commissioners and George A. Sampson of Weston & Sampson, Consulting Engineers of Boston, a program for improving the system was adopted as follows:

1. Construct a booster station and an elevated storage tank in the Highlands section.
2. Replace the old steam pump with a 2.5-mgd centrifugal pump with auxiliary gasoline engine.
3. Prevail upon the Braintree Electric Light Department to provide better service, by replacing about 2 miles of wires.

4. Install a double-action altitude valve at the Braintree standpipe.
5. Reinforce the distribution system by laying about 20,000 ft of 12-in. pipe, 5,000 ft of 10-in. pipe and 5,000 ft of 8-in. pipe.

The improvements to the Braintree Highlands water supply involved the construction of a booster station and an elevated storage tank at a cost of $50,000, replacing the reserve pump at the pumping station at a cost of $9,000, and providing an altitude valve at the Braintree standpipe at a cost of $3,000. These improvements, aggregating $62,000, were needed promptly. Therefore, it was decided that this sum would be borrowed and, since $17,000 relating to pumps and equipment must be retired within a five-year period, it was decided that the $45,000 balance should be borrowed for 15 years. Thus the Department would be under the necessity of retiring in 1947 $7,000 on these two loans, plus $5,000 on an outstanding loan, plus approximately $1,000 for interest, making a total of about $13,000 to be taken out of the current income.

The estimated cost of installing some 30,000 ft of new water mains was $180,000 and, if this sum were borrowed for a period of 15 years, the annual cost of retiring this loan would amount to about $13,000. The Department was not in a position to improve the distribution system in order to meet the requirements of the Fire Underwriters without some contribution from the town for this purpose.

Records disclosed that prior to 1917 the town paid the Water Department at the rate of $25 per hydrant for maintenance of fire protection. In that year the contribution was reduced to $500 and after a few years it was reduced to $1.00 per year. Since 1917 the town would have paid the Water Department approximately $270,000, computed at the rate of $25 per hydrant, as compared with about $8,000 actually paid.

In 1946 the Water Department had a total of 515 public fire hydrants, which at a rental rate of $25 would provide the Department with an annual income of $12,875. This income would be a material step toward financing a loan for the new pipe lines.

Faced with the above facts, the Water Commissioners adopted a public-relations program to create public awareness of the critical

situation and of the proposed remedy. This was accomplished by publishing the facts in the Annual Town Report and by personally contacting many prominent citizens and Town-Meeting Members. It was particularly important that the fundamental reasons for the improvements were fully understood by the members of the Town Finance Committee.

There is an interesting note in connection with the hydrant-rental program. The Fire Chief, who originally opposed the idea, since it substantially increased the budget of his department, soon became one of the staunch advocates of the program and did much to promote its adoption.

DISTRIBUTION-PIPE PROBLEMS

BY KENNETH W. ROBIE*

[*Presented at Superintendents' Round Table, Sept. 19, 1947.*]

THIS discussion about distribution-system problems is divided into two parts: first, the location and laying of distribution mains and service pipes; second, tests on bell-and-spigot pipe joints in which both lead and two kinds of self-caulking compounds were used.

Laying Mains and Service Pipes. About the year 1918, our town adopted the dual system of sewers and drains, and several years later a standard sewer-and-drain structure was adopted, consisting of a drain pipe over a sewer pipe (minimum diameter ten inches), both encased in concrete, with a minimum of six inches of concrete on all sides. In cases where the bottom was uncertain, three types of foundation were used: a concrete spread-footing, piles, and concrete piers tied into a footing designed as a continuous beam.

Several years later, after studying this structure, we decided to lay our mains on it for two reasons—a solid foundation and economy—the Water Department paying one-third the cost of the excavation for the combined trench. At current prices, say $1.25 per linear foot for excavation, the saving will be approximately 50 cents per linear foot.

One of the first problems encountered in laying a main on top of the sewer-and-drain structure was what to do at points where there were manholes. The first method we adopted was to go around the manhole, but this involved increased cost of pipe, due to the necessity of using two or more specials, and also meant some increase in friction loss, due to the extra bends. We finally adopted as standard practice putting the main through the manhole instead, except where a manhole occurred at a fairly sharp angle in the line of the structure, in which case we by-passed it, laying the main on gravel refill, well puddled, with 1/16th or 1/32nd bends where the main left the structure. In the case of a flat curve the deflection was made up on the

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joints and not more than nine-inch offset for each length of pipe. In the case of twin manholes the main was laid between them, the space between the main and the brickwork being caulked with jute. Where the distance between the top of the sewer structure and the finished grade of the street was between five and seven feet, the main was laid directly on the concrete with wooden blocking behind each bell in the usual manner. In cases where the structure was deeper than this, we used concrete or brick piers or else laid the main on gravel refill, in order to keep our main at the proper depth.

As a further development of the combined-utility trench idea it was thought that it would be economical to lay electric ducts and telephone ducts on shelves on either side of the sewer and water trench. This did not work out as well as we expected, due to the difficulty of excavating shelves by machine, and this idea was abandoned and the two utilities were laid side by side in another trench.

In new streets all the utilities are laid to each lot, a procedure which saves the cost of excavation and resurfacing when the lots are developed. The water and gas service pipes are laid on shelves on either side of the sewer-and-drain trench. We have now adopted the same plan for house service connections on old streets, in order to save excavation costs, time and resurfacing charges. Regulations have been drawn up by the Town Engineer, specifying the method of making sewer and drain connections, part of which, relating to combined trenches, is as follows: "After laying the pipes and placing the concrete encasement the drain layer shall allow the Brookline Water Department and any utility company, requesting the right, to locate and construct their services to the building or any other point on the premises, within the trench or trenches opened by him. He shall also allow them to excavate shelves along the sides of his trench and install thereon the necessary services. Within the limits of the improved pavement the trench shall be covered by a ten-inch slab of 3,000-pound Portland Cement Concrete having a bearing of at least one foot on undisturbed foundation on each side of the trench, reinforced by half-inch deformed bars of proper length, placed twelve inches on centers on the bottom and twenty-four inches on centers on the top, and the top of the slab to be two inches below the surface of the pavement."

Tests on Bell-and-Spigot Pipe Joints. We now come to the second part of our discussion, which will include a description of tests on bell-and-spigot pipe joints, in which both lead and two kinds of self-caulking compounds were used, in order to determine which kind of joint material would remain the tightest under severe conditions of settlement.

Three identical sections of 8-in. pipe were made up as follows: 4 lengths plus a 3-ft cut piece and 2 caps, two ¾-in. corporation cocks on top of the pipe at one end of the section—one connected to the street main with 100-lb pressure, the other used as a vent—and also one ¾-in. corporation cock at the other end on the bottom of the pipe, to serve the dual purpose of a drain and a means of pressure-gage attachment. The three test sections were blocked 6 in. off the ground in back of each bell.

The connection to the supply was through a ¾-in. copper-tubing goose-neck, 6 ft of extra heavy 1-in. rubber hose, a 1-in.-by-¾-in. curb stop, a tee on 1-in. galvanized manifold pipe, to test meter reading directly to 0.01 cu ft and thence to the main connection with 1-in. galvanized pipe.

The 3 sections were marked *A* (lead), *B* and *C* (compounds) and the joints were numbered from the end connected to the supply, there being six joints in each section. The joints were made up in the usual way by two experienced men, using 2 strands of jute for each joint, which left about 2½ in. of joint to be filled.

On July 14, pressure was applied to the three sections. It remained at 99 to 102 lb during the whole time of the test. After 3 hours the joints were examined and the pressure drops taken. *A* was tight and on *B* and *C* all joints were dripping. On *B* the pressure drop in 1 minute was 40 lb and on *C*, 10 lb. After 24 hours the drop on *B* was 24 lb in 5 minutes and on *C*, 11 lb, and the cap at *C*-1 moved out 1/16 in. *A* (lead section) was still tight, so the supply corporaton cock was shut, to see how much the pressure would build up by the expansion of the water, due to the heat from the sun. The water coming from the main was about 50° and the pipe lying in the sun was about 110°. This is aside from the test itself, but it was thought sufficiently interesting to record the fact that the pressure rose from 100 to 185 lb in 10 minutes and started a drip at joint *A*-6.

On July 16, all three sections were deflected in the following manner: a chain hoist was attached to each end and the whole section was raised, until the middle joint was about 2½ ft above the ground, and, to increase the deflection, a weight of 600 lb was placed on the low part of the section. The difference in elevation between the ends and the middle was then 26 in. on *A*, 30 in. on *B* and 15 in. on *C*. Joint no. 3 was then blocked up and the two ends were lowered to their original position, the intermediate joints remaining suspended. After this no further deflection took place.

Of special interest was joint *B*-3. In this case the compound pulled out on the upper side of the pipe, 1⅝ in. beyond the bell, releasing a small stream, which was reduced to a 5-second drip at the end of 10 days. Also of interest was joint *C*-1, the cap, which moved out ⅛ in. in 10 days.

Before deflection the leakage in *B* was 7½ times that in *C*, but the day after the deflection test the leakage on *C* was 16 times that on *B*. From then on both *B* and *C* gradually sealed up, until on the last day of the test they both showed only 1/15 of the original maximum leakage, but the ratio between the two held the same (16 to 1). In regard to *A* (lead) it should be noted that, while the leakage after deflection was 40 times that of *B*, practically all of this was from only one joint, *A*-4, whereas on *B* and *C* all the joints leaked. At the end of 10 days, the leakage on *C* was at the rate of 8 gal per mile per inch per day and on *B* it was ½ gal per mile per inch per day.

The intention of this test was to duplicate the severest possible condition of settlement. Although the double deflection of the pipes exceeded the worst condition that might be encountered in actual pipe-laying practice, it gives a very good picture of the behavior of the two types of joint.

RECENT DEVELOPMENTS IN THE CHEMICAL TREATMENT OF WATER SUPPLIES

BY LAZARUS RUBIN*

[*Read at Chemists' Round Table, Nov. 20, 1947.*]

THE subject covered by the title of this paper is rather a broad one and is not one that could be adequately covered in a brief discussion such as the present one. However, the science of the chemical treatment of water has undergone so many developments in recent years, including improvements of old methods and development of new techniques, that it is felt even a brief outline of some of the recent trends may be helpful in pointing the way to improvement in present water-treatment practice.

Chlorination. Perhaps the most common form of chemical treatment applied to water supplies is that of disinfection by means of chlorination. This phase of chemical treatment has been very thoroughly discussed at meetings of this Association and will therefore not be reviewed at great length here, except to point out that the practice of chlorination has undergone considerable modification in recent years, due especially to the studies of the function of the chloramines and of the difference in bactericidal properties of the chloramines and free chlorine, and to the effectiveness of break-point chlorination. With increased appreciation of this marked difference in bactericidal properties and the development of tests, such as the "flash" test and the so-called OTA test to distinguish between free chlorine and the chloramines, greater attention is being devoted to the type of residual chlorine present in the water supply. The growing use of break-point chlorination has resulted in waters in which there is not only an improvement in many cases over ordinary chlorination, as regards the destruction of coliform organisms, but also a greater elimination of all lactose-fermenting organisms. This type of treatment has been carried out with residual free-chlorine readings as high

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as 0.5 to 1.5 ppm in the treated waters, as compared with normal chlorination readings of about 0.2 to 0.3 ppm after 10 minutes' contact. In spite of these high residuals there have been relatively few complaints of chlorinous tastes from consumers.

Tastes and Odors. The elimination of tastes and odors is one of the problems which is quite common in the water-works field. The older methods, involving the use of copper sulfate for destruction of microscopic growths, aeration, and the application of activated carbon where filtration facilities are available, are still in common use today. However, an interesting variation of these methods is a recent one where a water supply, drawn from a reservoir where no filtration facilities were available, was treated with copper sulfate to kill certain types of odor-producing organisms and on the following day activated carbon was applied directly to the same reservoir. The odor-producing materials were adsorbed apparently by the activated carbon, which then settled to the bottom of the reservoir, together with the insoluble copper-hydrate sludge. The reservoir was in use all this time and at no time during or after this treatment was there any evidence of the presence of carbon or insoluble copper salts in any of the water drawn by consumers throughout the system.

One of the chief uses of break-point chlorination in recent years has been for the removal of odors. It has been found that, while ordinary chlorination is often effective in the destruction of odor-producing substances, it may in many instances merely increase the intensity of the odor caused by various micro-organisms or other organic matter. The use of break-point chlorination has resulted in an elimination of these odors and the presence of a slight chlorinous odor, which apparently has not been of sufficient intensity to cause objection by consumers. In many instances super-chlorination followed by dechlorination has been practiced to eliminate strong odors.

In recent years there has been some development of a new chemical agent, namely, chlorine dioxide, which is a strong oxidizing agent and has been used to eliminate certain types of odors which it has been difficult or impossible to remove with chlorine or any of the other standard methods of treatment. It has been found that the continued use of this chemical results not only in the elimination of the objectionable odors in the water but also in a gradual destruc-

tion of odor-producing organisms and organic matter present throughout the interior surface of the water-supply piping system.

While the use of ozone is not new, there has recently been a renewal of interest in the use of this chemical for the treatment of water supplies for the removal of odors and tastes, and an interesting paper on this subject appeared in the last issue of the JOURNAL, in which it is indicated that plans for the improvement of the water-supply system in the city of Philadelphia provide for treatment with ozone for the removal of tastes and odors.*

Corrosion. The problem of corrosion is one which has confronted the water-works field since public water-supply systems were first installed. Our original methods, involving neutralization of the acid condition of the water with alkaline reagents and deaeration, especially of industrial supplies, has been supplemented in recent years by several other types of treatment. The process of neutralization itself has undergone certain refinements, due especially to the work of Langelier. This work, based on the proposition that a water saturated with respect to its calcium-carbonate content will not be corrosive to iron piping, has led to the development of certain mathematical equations for the determination of the pH required and the amount of lime or soda ash necessary to reach the optimum pH for corrosive correction treatment. This newer method of applying alkaline reagents has resulted in an improvement in this type of correction treatment, except in the case of very soft waters, especially those from many of our surface supplies. Here the calculated optimum pH has been generally in the vicinity of 9.5 or higher and treatment to attain this pH has not resulted in any marked improvement in the corrosive properties of the water, especially with reference to iron piping. In general, it would seem that with waters having an initial alkalinity of less than 20 to 30 ppm this type of treatment has not been quite successful.

Several other types of chemical treatment for the reduction of the corrosiveness of water supplies have appeared. Perhaps the most notable one is the use of certain complex phosphates. Originally, so-called sodium hexametaphosphate was chiefly used for this purpose. At the present time, however, several other complex phosphates have

*JOURNAL of the N. E. W. W. A., Vol. 61:3, p. 247, Sept., 1947.

been found to have similar properties. It has been found that dosages, in general, on the order of 1 to 2 ppm have been quite effective in reducing "red water" troubles. It must be pointed out that this type of treatment is based not on a change in the corrosive properties of water but rather on treatment to change the properties of the interior surface of the piping with which the water is in contact. Apparently, prolonged application of certain phosphates results in the formation on the interior surface of the piping of a coating which renders that surface less subject to corrosive attack. While this type of treatment has been quite effective in eliminating "red water" troubles with iron pipe, there is not as much information available as to its effectiveness with copper and brass piping. In general, our experience along these lines has indicated no substantial effect of the use of polyphosphates in the protection of copper and brass pipe against corrosion. With lead pipe we have found, both in laboratory experiments and in actual water-works practice, that the use of polyphosphates does retard corrosion, if the pH of the water is on the acid side. However, with pH values at 8.0 and above, there is an increase in the corrosion of lead by water which has been treated with polyphosphates. This should be borne in mind when polyphosphate treatment is contemplated and where a considerable amount of lead pipe is present in the water-works system. Recently it has been found that polyphosphates in somewhat larger dosages (10 to 15 ppm), supplemented by either lime or sodium silicate, were effective in reducing corrosion in domestic hot-water boilers and hot-water lines.

The use of chlorine to combat corrosion is a fairly recent development. It has been found that, where corrosion was due to bacterial decomposition, as in certain mains, chlorination to kill off the bacteria resulted in a decrease in the corrosion effects. It has also recently been found that the corrosion of copper and brass piping in hot water systems, especially in return condensate lines, has been due to the presence of small amounts of ammonia in the original water supply. The use of chlorine for break-point chlorination of such supplies has resulted in the elimination of the ammonia and a reduction of the corrosive action.

Another approach to the corrosion problem has been the lining of the interior of the piping with an inert material. The use of cement

lining for this purpose is an old practice and is still in common use. Recently, it has been suggested that certain types of plastic paints be applied for such purposes and several manufacturers have already offered such paints. While there has not been much development along these lines, it must be pointed out that the use of plastic piping of various kinds to carry corrosive liquids in the industrial field is quite common and has met with general satisfaction.

Removal of Iron and Manganese. The presence of excessive amounts of iron and manganese in water supplies has been a problem of long standing. Here, while the predominant practice is still the use of aeration followed by filtration through coke and then through sand, other methods have also been used. The use of coagulation and filtration, especially at high pH, has been successful in the removal of manganese. There have been several instances where it has been found that the use of break-point chlorination, followed by sedimentation and filtration, has been successful in removing manganese from water supplies. The use of zeolites for the removal of iron and manganese has been developed in recent years and several such plants for the removal of manganese are in operation at the present time. The removal of iron by this method has not been as successful, because it is necessary for the iron to be in the ferrous form and in solution when applied to the zeolite filter. Waters of this type are not common, especially in Massachusetts. Where this type of treatment is used, however, it has been found that the regular ion exchange takes place and both iron and manganese can be removed. Another approach to the iron and manganese problem has been the use of polyphosphates. It has been found that the application of relatively small concentrations of certain polyphosphates, such as sodium hexametaphosphate, has been successful in keeping iron and manganese in solution and thus preventing their presence in the water from coming to the attention of the consumer. This type of treatment is best adapted as a temporary expedient for supplies where there is a sudden marked increase in either the iron or manganese content or where facilities for the removal of iron and manganese have not yet been developed, due to lack of funds or for other reasons. This type of treatment, however, is not advisable as a long-time practice.

Filter-Plant Operation. In filter-plant operation there has been a growing interest in the use of iron salts in place of alum for coagu-

lation. These salts are being prepared in more readily available form and recent experimental work has shown that in many instances, such as removal of manganese and use at very low or very high pH values, these chemicals compete quite favorably with alum. There has been a recent development in the application of alum to the solution by electrolytic means rather than the use of the standard alum salts. The use of electrodes made of sheet aluminum, immersed in the water to be treated, and the application of current through the solution has resulted apparently, in certain instances, in the formation of an alum floc, which had certain physical properties superior to that of ordinary alum. This method of coagulation is also of advantage where it is desired to keep the water at a fairly low pH. At the present time this type of treatment is applicable only to smaller supplies and where the difference in cost is not excessive. The use of various grades of activated silica to aid in alum-floc formation has been reported by a number of filter-plant operators.

Water Softening. In the field of water softening there has been considerable development of interest. The older lime and lime-soda processes of softening have been improved in efficiency by being used in conjunction with the Spaulding-type precipitator.

The use of the naturally occurring zeolites for softening has been supplemented in recent years by the development of synthetic carbonaceous and resinous types of zeolite materials. In the older type of zeolite there is an exchange of the sodium ions of the zeolite with the calcium and magnesium ions of the water and the resulting water, while soft, has the same or a slightly higher mineral content. The use of carbonaceous zeolites, which can be regenerated with an acid, results in an exchange of the hydrogen ions of the zeolite for the calcium, magnesium and sodium ions of the water, thus giving a water with a hardness close to zero and a considerably lower mineral content.

The recent development of resinous types of zeolites has yielded materials which remove not only the positive ions but also the negative ions, so that the use of a cation resin followed by an anion resin results in a water which is quite similar in properties to distilled water. The cation type of resins is regenerated with an acid, such as sulfuric, and the anion type of resins is regenerated with an alkali, such as sodium hydroxide. Smaller units are provided with replace-

able cartridges, containing both types of resins, and therefore eliminate regeneration. These resins, of course, will not remove silica, organic matter and other non-ionizable material. However, the resulting water is quite satisfactory in place of distilled water for most industrial purposes and many laboratory purposes. Since this type of unit is considerably more economical as a rule than the distillation methods for preparing distilled water, it is coming into more extensive use, especially in industry.

Addition of Sodium Fluoride. Another aspect of the chemical treatment of water which is developing at the present time is the addition of a chemical to the water for what Wolman has called "mass-medication" purposes. As you all know, it was found some time ago that, where the fluorine content of the water supply of a community was greater than 1.5 to 2.0 ppm, a dental condition known as "mottled enamel" and described as a dark discoloration of the enamel of certain teeth may be found among some of the consumers of the water supply. However, many recent studies have indicated that, where the fluorine content of the water supply is about 1.0 ppm, there is a marked decrease in the incidence of dental caries among the population, as compared with communities where the fluorine content is much less than this amount, and there is no occurrence of "mottled enamel". As a result of these data, there has been an increased demand on the part of various groups in several communities that the water supply be treated by the addition of sodium fluoride, so that the optimum concentration of fluorine will result, in anticipation that, as a result, there will be a decrease in the incidence of dental caries. At present, some dozen communities, scattered throughout the United States and Canada, have undertaken this type of treatment and in most of these communities a parallel program of dental surveys is being carried out, to determine whether the expected beneficial effect will result. However, this type of treatment is still in the experimental stage and it will be several years before convincing results can be obtained. There has been some questioning of this type of treatment of water supply and it has been compared, for instance, with the agitation some 20 years ago for the addition of iodine to water supplies for the elimination of goiter. Both the economic and the scientific aspects of this type of "mass medication" have as yet to be exactly evaluated.

WORK OF THE NEW ENGLAND FORESTRY FOUNDATION ON WATERSHEDS

BY HARRIS A. REYNOLDS*

[*Read November 20, 1947.*]

FOREST growing calls for a longer look into the future than any other crop, but we know that our future prosperity and our national safety depend in large measure upon the conservation of our forest resources. We must plant if our children are to reap.

Throughout World War II wood was the most critical material. Ships were held in Boston Harbor because of lack of dunnage and German war prisoners were used to cut the scrubby pitch pine on Cape Cod for this purpose. Even now the scarcity, and hence the price, of good lumber is a big factor in retarding the construction of homes. These experiences have awakened the public as never before to the need for better forest management.

Here in New England we have a natural forest country with three-fourths of our 40,000,000 acres suited only for timber production. But through mismanagement—overcutting and lack of both fire control and suppression of insects and diseases—the average forest acre is producing only about 100 board feet per year. Under proper management it should be growing 300 to 400 board feet annually. Accurate statistics are not available, but from those we have it is conservative to say that fully 20% of our citizens get all or a large part of their living from the growing, harvesting, manufacturing, transporting and marketing of wood products. We have millions of acres that have produced good timber in the past but are now lying practically idle and not producing enough timber to pay the taxes. At the same time, we are importing three-fourths of our lumber from other states and countries. Much of it is coming from the Pacific Coast at a cost for freight alone greater than the cost of producing good timber on our own lands with our own men.

On its way from the stump to the ultimate consumer wood in-

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creases in value more than ten-fold. The differential between stumpage value and retail prices of the finished articles, therefore, represents that much industry. If we can increase our forest production by 100 board feet per acre annually—and we know that twice that figure is possible—we shall provide, at prevailing stumpage prices, the raw materials for a $300,000,000 industry on our 30,000,000 acres.

The most difficult problem before foresters and conservationists in this country has been to find a practical method by which forest lands may be brought under management. For nearly half a century we have considered forestry as a public function and have devoted most of our energy to the establishment of national, state and town forests, giving of advice to owners by public foresters, finding an equitable method of forest taxation, and public protection of the forests against fire, insects and diseases. We have made some progress, but today less than 6% of the forest land in New England is in public ownership and, therefore, under the direct management of the forester. For more than 300 years we have followed the custom by which an owner has sold his timber to the highest bidder with no restrictions on how it should be cut, with the result that the buyer or operator has generally clear-cut the area and another crop cannot be expected for 50 to 100 years. It is this custom of clear-cutting over large areas which is more responsible for our idle forest lands, largely covered with worthless growth, than the combined damage by fire, insects and diseases. Under forest management forests are cut selectively and the mature growth is harvested at frequent intervals. Thus the forest capital of the owner is preserved and a more regular income is insured.

Three years ago the Massachusetts Forest and Park Association appointed a committee, composed of woodland owners, wood manufacturers, business men and foresters, to make a thorough study of this problem. Acting upon its recommendation, the Association, in the summer of 1944, organized a separate corporation known as the New England Forestry Foundation. It was set up under the Massachusetts law as a non-profit corporation, to be directed by not more than 50 residents of New England, for the sole purpose of giving complete forestry service to owners at cost. It is an experimental approach to the problem and the organization has no precedents to follow.

The plan of operation is to establish forest-management centers in forested districts, each center to serve about 200,000 acres. The size of the area served depends upon the amount of business obtained. Each center is under the direction of a trained forester and it is planned that the Foundation will acquire in each center about 1,000 acres, which will be used to demonstrate the principles of forest management. Owners enter into management agreements by which the Foundation, acting as an agent of the owner and subject to his approval of each operation and expenditure, will apply the principles of forest management to the property.

In each center the Foundation plans to help organize and train forestry crews, which will be under the direction of practical foresters. These crews under contract as private operators, directed by but not in the pay of the Foundation, will do all types of forestry work for clients. To carry out the management plans prepared by the Foundation for a given property, these crews will do planting, pruning, weeding, improvement cutting, logging, road and trail building and all other needed work for the protection and development of the property as a forest investment.

One of the most important functions of the Foundation is to study the markets for the forest products of a center and thus, by proper grading of the material to be sold, to provide a service to the industry of the region, as well as to obtain the best possible prices for the owner. It has been demonstrated in many instances, not only here but in other states, that an owner can make more money from a sale of timber, after paying for the services of a forester, than he could have made without such service. The real gain to an owner is in the fact that his growing stock of forest capital has been conserved.

For the first 15 months of its existence the Foundation was unable to hire a full-time forester on account of the war. Therefore, it has been actually operating only a little more than two years. At the present time it has eight foresters on its payroll and is engaged in the establishment of six management centers. Three of these centers are in New Hampshire, two in Massachusetts and one in Vermont. It is using the services of three forestry crews to do work on the lands of clients, each under the direction of a trained forester. It has supervised the cutting of more than 5,000,000 feet of timber for

clients, which means that the cutting was done according to forestry principles. It has 145 clients located in 95 towns. It has completed the plans on about 55,000 acres and is working on about 10,000 acres more. It has found on the lands of its clients 108,000,000 board feet of timber, worth at present stumpage prices four-fifths of a million dollars. What, when and how timber on those lands shall be cut will be determined by the forester rather than by the buyer, whose chief interest is to take everything from which he can make a profit. Under a management plan it is seldom that more than 30% of the merchantable timber is cut at one time and the future cutting interval on most tracts is set at five years. On large properties a small logging crew will be kept constantly employed, but in no case will it cut more in one year than the annual growth on the property.

In the management of forest properties, the Foundation recognizes that other factors than the production of timber must be considered. So far its management plans call for five classifications of woodland properties: farm, commercial, industrial, recreation and watershed forests. Under the recreation forest comes the large estate, the game preserve and the wild public park. For the industrial forest the plan provides for the growing of a particular species used in the factory of the owner. It is the watershed forest in which your group is especially interested.

The prime objective in the management of a watershed forest is to protect and build up the forest floor as a supplementary reservoir. Water boards are charged with the responsibility of providing both quantity and quality of water for public use. Therefore, any operation on a watershed demands extreme caution against pollution and erosion. While the objective of forest management is to grow the maximum of commercial timber of which the site is capable, all plans of the forester must be squared with the prime purpose of the area. On the other hand, commercial species will conserve the rainfall just as well as weed species. There are no areas in public ownership on which the practice of forest management can be applied to greater advantage than on watersheds. The water board is comparatively free from political influence and pressure from groups seeking recreation facilities. This cannot be said of the national, state or town forests. Besides, the water board has more freedom and usually more funds

available to do the things that ought to be done for the improvement of the forest.

In his management plan for a watershed the forester must give special attention to the protection of the forest against fire, insects and tree diseases. The loss by fire in a commercial forest is mostly the value of the timber destroyed, but a fire on a watershed not only destroys the timber but the forest floor, which may take many years to restore. If a fire occurs in hilly country, erosion may present a special problem. After a fire there is likely to be more silt, ashes and other debris carried into the reservoirs. To get the burned area reforested quickly with commercial species often requires planting.

Since forest fire is the most spectacular enemy of the forest, let us consider some of the measures that should be taken to cope with it. Apart from the help that may be expected from the city fire department or the forest warden with fire-fighting equipment, there are three steps that every water board should take for the protection of its forest. These steps are: patrol, the removal of hazards, and roads, trails and waterholes.

Patrol, or the guarding of the forest, is the most effective form of prevention and for the money expended gives the best results. Every town which has given patrol a fair trial has found it to be effective. The Cape Cod Forest Fire Prevention Experiment, covering a period of three years and conducted about 20 years ago, proved that by combining education, patrol and suppression, the fire losses were reduced 80%, with 20% less money than by using suppression alone. As a matter of fact, patrol is used only on days of high fire hazard, which even on Cape Cod seldom exceed 25 in number. The patrolman should be equipped with some knapsack pumps and other hand tools, to enable him to extinguish incipient fires or hold them in check until help arrives. His main job, however, is to educate and alert the public to the danger of using fire at such times and to keep people out of the woods.

Let me cite one example where patrol might have prevented a heavy loss during the recent fire season. Thomas J. Kennedy, Superintendent of the Fitchburg Water Department, informs me that a fire, which occurred in Fitchburg and destroyed valuable trees on the watershed, covered about 2½ sq mi and cost $25,000 for fire

fighting. The annual interest on that sum, at 5 per cent, would be $1,250. At $8.00 per day for a patrolman, that interest money would pay for about 7 patrolmen for 20 days annually in perpetuity. No such force would be necessary for adequate patrol of the average woodland. With such a force, however, to guard the forest, that fire either would not have started or would have been extinguished in its incipiency. Why, therefore, should we not insure our forests against such losses by guarding them on days of high fire hazard?

The removal of fire hazards is a precautionary measure that too few towns and forest owners employ. An open field of broom grass in or near a forest is a strong temptation to the fire bug. Such areas should be reforested as soon as possible. The removal or covering with earth of all old dumps, often found about cellar holes and sometimes in unexpected places, may prevent a fire caused by broken glass. Not only should all hazards within the forest be removed but the possibility of fire's approaching the forest from adjoining lands should be studied. This is especially true where railroads or main highways are located in the vicinity of the forest. Town dumps are also a fruitful source of bad fires and these should not be permitted near a watershed forest.

No amount of fire-fighting equipment can cope with a big forest fire, unless it has freedom of access to it. Each watershed forest should be made readily accessible, by main roads through it and by spur truck or logging roads, so that the fighters may be able to reach any fire quickly. The construction of water holes at strategic points is a good investment, since the water hole in the forest corresponds to the hydrant in the city and since much of our best equipment is useless without water.

The Foundation has made management plans for three water boards in Massachusetts: those of Russell, Pittsfield and North Adams. Here are some of the silvicultural practices applied by the Foundation in the management of watersheds:

Planting. Since planting is the most expensive form of reforestation, the Foundation does as little as possible. There are situations, however, where planting is the only method by which to establish a forest floor within a reasonable time and the judgment of the forester as to the species to use for a given site is important. Too often we

have used species unsuited for the location and sometimes of little commercial value. It requires about two man-days to plant an acre with 1,000 trees.

Pruning. It has been proved that, by pruning the limbs from white pines when they are 2 to 4 in. in diameter at breast height, clear lumber can be obtained when the tree is cut. The trees are pruned to a height of 17 ft, thus insuring one 16-foot log which contains just about half of the commercial timber in the tree. Only the final-crop trees are pruned, or about 250 per acre. It takes one hour for one man to prune enough trees to make 1,000 board feet of lumber. At today's prices the unpruned or knotty box-board lumber is worth about $50.00 per thousand, while the clear or pruned lumber sells for $150.00 and up. In other words, for the investment in pruning of $1.00, the lumber in the tree can be increased in value $100.00. There is no more profitable undertaking in the field of forestry. There are thousands of acres on the watersheds of New England that contain plantations, a large percentage of which are at the age when they could be pruned to advantage.

Weeding. Weeding is the process of removing the weed species to give the commercial species a better chance to grow. On cut-over land it often happens that the area is covered with coarse sprout growth and weed species that overtop the seedling pines, ash, oaks and other trees of commercial value. By cutting out these weeds at the right time, when the growth is still small, a good crop can be obtained. One trained man with a machete can weed an acre a day, if it is done at the proper time, and this is a much cheaper method of getting a young commercial forest established than by planting. If this treatment is delayed too long, it is uneconomical and the owner must wait until the time when he can make an improvement cutting.

Improvement Cutting. An improvement cutting is one that is intended to increase the growth on the remaining trees. When a tree of commercial species is given more light and the root competition has been reduced by the removal of deformed, diseased or weed trees that have hindered its growth, it is not uncommon for such a tree to triple its annual growth. It is entirely possible to double or triple the growth of wood on an area by proper improvement cutting alone.

This is one of the most profitable and most needed operations in the forests of New England. It should, however, be delayed until the materials taken out are of such size as to be merchantable. In this way the operation is made to pay for itself. Here is where a production crew of the Foundation can be most serviceable to the owner.

Besides the planning and carrying out of the above operations, the Foundation under management agreement with the owner acts as his agent in the marketing of forest products. Its job is to relieve the owner of the details of management, to obtain the best possible prices for his materials and to build up his forest capital. No operation is started or expense incurred without a work order from the owner, after he has been convinced of the desirability of the undertaking. The Foundation is not in business to make money for itself, but to bring more and more forest land under profitable management. Its charges, therefore, are the actual cost to it of doing the work properly.

It is conservative to say that, at present prices for logs and pulpwood, the average forest acre which has been brought up to capacity production should show an annual net profit of about $2.00. Since the growing of timber is a by-product of the watershed lands and since the presence of forest growth on these lands is essential to the main objective, it would seem to be good business to grow commercial timber on these areas. Any money made from the forestry operations will either reduce the cost of water to the citizens or help to lower the tax rate.

SMALL GROUND-WATER SUPPLY SYSTEMS FOR STATE PARKS

BY ARNOLD E. HOWARD*

[*Read November 20, 1947.*]

WHEN first invited to present a paper before your organization on the subject of small ground-water supply systems for our state parks, I rather hesitated to do so, feeling that my contribution to the subject of water-supply systems, in so far as you gentlemen were concerned, would be rather insignificant. However, after giving the matter more thought, it occurred to me that perhaps our problems, while normally simple of solution, might be enough different from those you ordinarily encounter, to be of some interest. In any event, I felt it would at least give me an opportunity to put in a few good words about our parks and what they have to offer to the public from a recreational point of view.

Before going into the details of our water-supply problems, I would like to take a minute or two and briefly describe our park system, its purpose and the facilities which it has to offer.

The Division of Parks and Recreation, to which I am assigned, is one of the five divisions of the Department of Conservation as established by the State Legislature in 1941. Under the provisions of the law creating this Division, its functions are to develop, operate and maintain recreational facilities on state parks, state forests and state beaches, which are located on areas under the jurisdiction of the Department of Conservation. None of these areas, by the way, are located within the Metropolitan District.

At the present time there are, under our jurisdiction, 7 state parks, one state beach—Salisbury Beach—and 23 state forests on which recreational areas have been developed. They are located all the way from the New York state line, at the western end of the state, to Brewster, mid-way on Cape Cod.

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In general, all of our recreational areas have been developed for two distinct types of use, the first being designated as day-use areas and the other over-night areas. Under the first type, as the name implies, facilities to take care of the picnicker have been developed, including toilet facilities, water-supply systems, parking areas, shelters, bathhouses, beaches, picnic tables, fireplaces and concession buildings. For the over-night areas, toilet faciiities, drinking water, cabins, tent platforms, ground tenting sites, fireplaces, bathing facilities and shelters have been supplied.

In passing, I would like to point out that, in my opinion at least, had it not been for the Civilian Conservation Corps (the C.C.C.), our parks and recreational areas would, for the most part, still be undeveloped. Between the years 1933 and 1941, this organization set up over 40 camps on these parks and forests, 200 men to a camp, and practically all of the recreational facilities now available to the public on them are the results of the program initiated by the Department of Conservation and carried out by the boys and veterans of the C.C.C. All of the water-supply systems, which I shall briefly describe to you, were actually constructed by C.C.C. forces.

Because of the location of our parks and forest recreational areas—some high in the hills of the Berkshires and others on the sandy sections of Cape Cod—our water-supply problems are many and varied. Geologists have been brought into the picture on some of our problems, while the experience of local farmers was found invaluable in working out a solution at other areas.

One of the more difficult problems which we were called upon to work out was that of finding a suitable water supply for a proposed development on the October Mountain State Forest in the town of Washington. The master plan for this forest called for the development of a camping and cabin area around the shores of Felton Lake, an artificial body of water created with C.C.C. forces in 1935, high on the west end of this forest. On the basis of the ultimate development of this area, it was estimated that a maximum of 500 persons could be accommodated daily. Using a figure of 30 gal per person per day, we found it would be necessary to locate a water supply which would furnish a minimum of 15,000 gal per day. To provide for peak loads, it was estimated that 30 gal per minute would be required.

With the hope that a suitable spring might be found, which would supply this water, the entire mountain-side back of the camp location was scoured, but no springs could be found. Solid rock was found to exist everywhere within a few feet of the ground surface and all indications were that we would have to look well below the surface for a supply that would meet the requirements of the area. At this stage, a call for geologists was made and the National Park Service, under whose jurisdiction the C.C.C. camp which was doing this work came, sent two of their geologists to the site for the purpose of making an investigation. As a result of their work, it was estimated that water might be encountered somewhere in the vicinity of 350 ft below the ground at the site of the proposed well, which was at Elev. 1,838.

On the basis of this information, a contract was let and work started. An 8-in. wrought drive pipe, fitted with long drive couplings, was driven to bed rock and an 8-in. bore carried 10 ft into rock. A 6-in., full-weight, wrought drive pipe was tightly driven into a tapered hole, a tight joint thus being made in the bed rock, and the concentric space between this pipe and the bed rock was grouted with neat Portland cement. Below the tapered hole a well 6 in. in diameter was drilled into bed rock.

At an actual depth of 358 ft below ground line, water of sufficient volume was found and a 24-hour pumping test was made, to remove the sediment caused by drilling and to show the net yield of water. As a result of this test, it was found that the well could safely supply 30 gal per minute, the amount which had previously been set up as a minimum requirement. It is interesting to note that water was encountered within 8 ft of the depth where it was estimated to be found —358 ft against 350 ft.

The drilling of the well and the laying of a portion of the distribution-pipe line were the only parts of this water-supply system completed by 1940, at which time the C.C.C. camp was abolished. The plans for this installation called for pumping the water to a concrete storage reservoir, from which it was to be fed by gravity to the various parts of the proposed camp.

No funds being made available with which to complete the proposed development of this area, it remained at a standstill until 1946.

At that time, the Berkshire County Council, Boy Scouts of America, was in need of a summer camp location and became interested in the Felton Lake site. Prospects of receiving the necessary state funds to put the area in usable condition being considered remote, the Department expressed a willingness to lease the area to the Boy Scout Council, provided the necessary legislation could be passed. A bill was subsequently introduced and was passed at last year's session. The camp has now functioned for two seasons and the water-supply system has been completed and put in operation by the Scout camp.

In direct contrast to the problems encountered at the October Mountain Forest location, the development of a water-supply system at the Roland C. Nickerson State Forest Park in Brewster, on Cape Cod, was comparatively simple. This park, a 1,700-acre tract of woodland, was presented to the Commonwealth by the heirs of Roland C. Nickerson in 1934, for park purposes. Its chief assets are five large ponds of clear, sparkling water and sandy beaches, around the shores of which are wooded areas, ideally adapted for camping purposes, as well as for day use.

A C.C.C. camp was built at this park in 1935 and the construction of recreational facilities was soon under way. In 1937, the National Park Service, under whose jurisdiction this camp came, made it a V.C.C. camp, all of its members being veterans of World War I. A master plan for the ultimate development of the entire park was prepared at this time and all projects were carried out in accordance with it.

As in the development of all of our recreational areas, first thought was given to the construction of suitable toilet facilities and drinking-water supplies. It had been previously determined, as a matter of policy, that wherever possible, flush toilets should be provided and the National Park Service, whose approval was required on all projects, was in entire agreement on this point.

Flax Pond, being the pond nearest to the main park entrance on Route 6, was selected as the first body of water at this park, around whose shores recreational facilities should be developed, and a layout plan was prepared, indicating day-use facilities on the south shore and camping facilities on the east and north shores.

From the layout plan, which showed the general types of facili-

ties to be constructed, detailed working plans were prepared and, from these plans, we determined the number of persons for whom to provide. Four camping areas around this pond and one camping area on the shores of Cliff Lake, adjoining this area, provided 180 tent sites which, with an average of 4 persons per tent, gave a possible maximum daily population of 720.

Because of the topography, it was determined that two independent water-supply systems for this section of the park would be more economical than one and, consequently, one system was developed for the day-use area on the south side of Flax Pond, the second system taking care of the four camping areas on Flax Pond and the large camping area on Cliff Lake.

Previous to the time when the master plan for this park was prepared, two small comfort stations had been constructed, one in the picnic area and one in the camping area. Two separate shallow wells, with gasoline-operated pumps and pressure tanks, supplied the water for these two buildings. Drinking water came from hand-operated force pumps.

In the design of the water-supply system for the overnight facilities, a figure of 21,600 gal per day and a maximum hourly consumption of 1,500 gal were used, the daily consumption figure being based on 30 gal per day per person and the maximum hourly consumption figure based on the number of fixtures in use at times of peak loads.

Since we knew the requirements which must be met, our next step was to locate a source of supply which would satisfy them. A check of the depths of wells on property adjacent to the park showed that pumping was done from about the same water-level in each case. With this information at hand it was figured that, at the site selected for the well, water should be encountered at a depth of approximately 85 to 100 ft below ground surface.

As an alternative to a single tubular well, driven to the depth mentioned above, consideration was given to the possibility of obtaining the required volume of water from a series of shallow tubular wells at a lower elevation, near the shore of Flax Pond.

A test well was subsequently driven at a location about 150 ft southwest of the pond to a depth of 30 ft without reaching water, and another test well was driven to a depth of 20 ft in a steep gully,

about 50 ft from the shore of the pond. Water was encountered at the latter point at a depth of 9 ft and it was found possible to pump from this well at the rate of at least 12 gal per minute.

With these results to work from, we shifted the design from a single deep tubular well to four shallow tubular wells. These wells were driven at the location last mentioned above and were located in two rows, with a collector pipe between them. In order to eliminate the possibility of any one well's drawing water from the local source of any of the other wells, they were so spaced that there would be not less than 25 ft between them. The layout is such that, if additional wells are found to be needed in the future, they can easily be tied into the existing setup.

Each of the four present wells consists of 2½-in. well pipe and a 2½-in. by 36-in. open-end well-point, the lower two feet having five rows of holes, ⅜ in. in diameter, spaced 2 in. from the bottom, the holes reamed to ⅝ in. in diameter on the outside. At a point four feet below ground a 2½-in. long-sweep tee is fitted to the well pipe with one lead goose-neck, 18 in. long. A 2½-in. gate valve with service box is installed beyond the goose-neck and then a 2½-in. line to the 4-in. collector pipe. Each well is capped at the top, about one foot above ground. The collector pipe, of galvanized steel, 4 in. in diameter, runs to the pump house, where it is reduced so as to enter a 3-in. sand chamber of standard make.

Pump specifications called for a pump which would overcome a total head of 131 ft, consisting of a delivery head of 86 ft from pump to storage tank, a maximum suction lift of 25 ft and a friction head of approximately 20 ft.

With electric power available in the park, an electrically operated pump with 3-hp motor was installed and, except for minor repairs, has functioned very well during the six years it has been in use. Operation of the pump is automatic, control being regulated by means of a float system in the storage reservoir. The pump has a capacity of 1,800 gal per hour and is capable of working against a pressure of 125 lb per sq in. It has a 2½-in. suction line and a 1½-in. discharge line.

The storage reservoir for this system is of reinforced concrete, circular in shape, with a capacity of 25,000 gal. The cover is also

of reinforced concrete with a manhole through it. Since the reservoir is located on a hill, not far from one of the camping areas, the possibility of its disrupting the scenic beauty of the vicinity was forcibly brought to our attention by the landscape architect. To keep him happy, it was agreed to sacrifice a few feet of elevation and the tank was partially buried in the ground. Proper planting of vines and trees will, in time, hide the exposed part of the tank.

From the storage reservoir, distribution to the various points around Flax Pond is through 3,700 ft of pipe in sizes from 4 in. down. For pipe sizes of 4 in. to 2 in. asbestos-cement pipe was used and galvanized wrought pipe was used for sizes smaller than 2 in.

The average depth of pipe trench on this job was 3 ft, freezing not having to be considered, because of the fact that all recreational facilities are closed after September and the water system is drained.

Available pressures at the many outlets on the system vary from 36 lb per sq in. down to 16.5 lb per sq in.

While costs of work done in 1938 are way out of line as compared with present-day prices, I will just state them as a matter of record:

	Material	*Labor*	*Total*
Wells and Pump House	$1,670	$ 2,798	$ 4,468
Storage Reservoir	706	3,750	4,456
Distribution System	2,133	9,387	11,520
Total	$4,509	$15,935	$20,444

The labor was all C.C.C. labor, except $345 for skilled work, and was based on a figure of $2.50 per day per man.

Probably the most compact and least troublesome ground-water supply system which has been installed at any of our recreational areas is the one which we built at the Pittsfield State Forest in 1937 and 1938 as a C.C.C. project.

Because of the splendid opportunities at this forest for winter sports, especially skiing, our problem was to design and construct a system which would function on a year-round basis, with a minimum of maintenance and operation. The facilities to be served by this system were two comfort stations having flush toilets, a ski lodge having a kitchen, drinking fountains in a picnic area, a superin-

tendent's dwelling, a service building and garage, and two fire hydrants. All of these facilities are located in what is known as the Parker Brook Area, at the foot of several ski trails coming off the mountain side to the west.

On the basis of the number of fixtures to be in operation at this area, it was estimated that a minimum of 4,850 gal per day would be required. With both hydrants in use and supplying pressure of 40 lb per sq in. to ½-in. nozzles, a flow of 46 gpm was found to be required.

An investigation of the mountain-side had been made the previous year for possible sources of ground water and a spring was discovered, which looked good. A weir was established on the overflow stream from this spring and records were obtained as to its volume of flow. The results indicated a minimum flow of 3 gpm in dry weather and a maximum flow of 11 gpm at other times.

Being satisfied that the spring could supply sufficient water to fulfill the requirements of the Parker Brook Area, we went ahead with the design and construction of the system. The spring was located at a distance of 2,500 ft from the Ski Lodge, the nearest facility in the recreation area, and was 272 ft higher than the floor of this building. This assured us of sufficient head to operate all fixtures in the area below.

Boxing the spring, to keep surface water and other foreign matter out of the system, was accomplished by constructing a 4-ft-square box, 4 ft high. The upside of the box consisted of an 18-in.-thick wall of stone, laid dry, the other three sides being of concrete, 6 in. thick. The cover of the box was also of concrete, 3 in. thick, with a 2-ft-square manhole through it. To provide air circulation, a 4-in.-by-8-in. opening was left in the downstream face of the wall above the water level, screened to keep out vermin. The outlet from the box is a 1½-in. pipe with a strainer over the end. Just below the box a 1½-in. gate valve was installed, which was reached through a 4-in. vitrified-tile-pipe gate-box. To provide for possible future expansion, a 1½-in. cross was installed in the line between the spring and the storage reservoir, with two sides plugged. Additional spring supplies can be tapped into the supply pipe at this point, if found necessary.

The storage reservoir, of reinforced concrete, is 13 ft square by

13 ft high and is located 230 ft downhill from the spring. Its capacity is 10,000 gal. The difference in elevation is 70 ft. The walls are 12 in. thick and the top is 4 in. thick. A 2-ft-by-2-ft manhole through the top provides access to the tank, should the need arise. The floor of the tank is pitched 3 in. to the center and connected to a 3-in drain pipe. The 1½-in. feed pipe and 3-in. discharge pipe are both located at a distance of 4 in. from the bottom of the tank, with a 3-in. overflow pipe located one foot down from the top.

Control of the distribution line and the drainage line are by means of 3-in. gate valves, located in a manhole just outside the reservoir. The distribution system comprises 2,100 ft of 3-in. galvanized-steel pipe and 1,000 ft of 2½-in. to 1-in. steel pipe.

Because of the fact that most of the facilities at this area were planned to be kept in operation during the winter months, as well as during the summer months, a condition not existing at any of our other areas at the present time, all pipes had to be laid below frost line. With most of the line located in heavily wooded terrain, it was found that a 4-ft cover over the pipe was sufficient.

Trenching was started on Oct. 25, 1937, and for the first 600 ft comparatively easy going was encountered. Excavation, for the most part, was through gravel. However, the remaining trench work was one continuous headache. Excavation material was 75-90% hardpan and ledge and, to add to the difficulties, more than 2 in. of rain fell in this section during the first 20 days of operation. As a result, considerable trouble developed in keeping the trench free of water. Work was halted on Dec. 28, because of frost conditions, and was reopened on March 25 of the following year. Ground-water conditions were again found to be troublesome, with more than 5 in. of precipitation in the period preceding the reopening of the work.

In spite of these difficulties, the work was finally completed and the system put into operation later that year. It has been in operation for nine years now and requires practically no attention in so far as operation and maintenance work are concerned.

As an aid in locating the pipe line at some future period, should trouble develop, concrete markers were prepared and have been set in the ground over the pipe line at regular intervals throughout its length, as well as at all points where the line changes direction.

The total cost of this system was $19,279, of which $2,044 was for materials, the balance, $17,235, being the C.C.C. labor costs, based on $2.50 per day per man.

The water-supply system which, at the present time, is the least satisfactory of all the systems which supply water to our recreational areas, but which serves its purpose temporarily, is the one at the Mohawk Trail State Forest. My only purpose in mentioning this system is to bring out the point that, should you ever encounter a similar situation, the set-up we are using is workable.

Many years ago, at this forest located in the town of Charlemont on Route 2, the Mohawk Trail, a small roadside recreational area was constructed, probably the first of its kind on state forests in this State. To provide water for the operation of the fixtures in the toilet building constructed in the area, a dam was thrown across the brook which came down the mountain-side on the opposite side of the highway and a pipe line was laid from it to a concrete storage reservoir. From the reservoir a distribution pipe carried water to the comfort station by gravity. A riser, with spring faucet attached, provided water for drinking and cooking purposes.

Very little thought apparently was given to the possibility of water pollution at that time, the feeling evidently being that, coming from a mountain-side where the public would not be apt to go, the stream would be perfectly pure. Moreover, the chances are that, over the years, its waters were free from bacteria characteristic of pollution. However, the time came when the precaution of having our drinking-water supplies tested annually by the Department of Public Health was established and, while their examinations from year to year showed the water to be perfectly safe for culinary and drinking purposes, they would not approve of the set-up as it then existed. This was perfectly proper, as it was a supply used by the general public and the slightest possibility of pollution could not be tolerated.

Without the necessary funds for a permanent installation to correct this situation, a temporary solution was looked for and the answer found in the "Manual on Emergency Sanitation", published by the Massachusetts Committee on Public Safety during the war period. On page 21 of the manual was described a carboy solution feeder for use with small water-supply systems. Its application to

our problem was comparatively simple and, with the coöperation and assistance of the Department of Public Health, the chlorine feeder was put into operation three years ago and has filled the needs of this system satisfactorily during that time. The apparatus consists of a 5-gal glass carboy, a tight-fitting two-hole rubber stopper, a glass breather tube, a glass siphon tube with rubber-hose connections, a separator for spacing and holding the tubes together and a calibrated orifice. This apparatus was suspended over the intake to the storage reservoir and the chlorine solution added to the carboy as needed. Daily checks of the residual chlorine by the supervisor at this forest insure a drinking-water supply which is safe and about which very little, if any, complaint is made.

As a part of our post-war planning program, we have prepared plans and specifications for the construction of a slow-sand filter as a part of this water-supply system and, as soon as the legislature provides the necessary funds, this project will be carried out.

The simpler types of drinking-water supplies which we have developed at our recreational areas are the driven well and the dug well with hand pumps and the boxed spring with gravity feed to a bubbler or water outlet. The driven wells which have been installed are, for the most part, on areas in the southeastern part of the state, including Cape Cod, where sandy soil makes this type of water supply easy to obtain. Boxed springs and dug wells are about evenly distributed on areas in other sections of the state.

A boxed spring makes an ideal drinking-water supply, for, once the spring is enclosed and a pipe line laid to a suitable outlet, very little attention need be given to it. The principal precaution which we have found must be taken in developing a spring is not to blast rock or ledge in its vicinity. We have had several experiences of this nature where, in an attempt to enlarge a spring by blasting, it was lost completely.

Dug wells with hand pumps have been developed at many of our areas, where other types of water supplies have not been available, but they are probably the least desirable type, in so far as public areas are concerned. Either the water table drops at just the time of heaviest use or the pump goes out of commission, sometimes as a result of over-enthusiasm on the part of some youngster in pumping.

In the development of drinking-water supplies of this type, we have departed from the former practice of laying up a dry-masonry wall and now use concrete pipe, perforated with holes, up to within 8 or 10 ft below the ground level. The upper pipe sections have solid walls and extend to a distance above ground such that surface water can be excluded. As a precaution against the seepage of waste water into the well, the pump is offset from the well at least 15 ft.

At three of our areas—namely, Salisbury Beach Reservation, Standish Monument Reservation in South Duxbury, and Robinson Park in Agawam—we are fortunate in being able to tie into town water-supply systems, which provide good water at a reasonable cost.

I should like to take this opportunity to express publicly my personal thanks, as well as that of the Division of Parks and Recreation, for the splendid coöperation given by the members of the Engineering Division of the State Department of Public Health in matters pertaining to the development and operation of our water-supply systems. I might add also that, at least once a year, and oftener, if we feel the necessity for it, this Department analyzes each and every one of our drinking-water supplies and advises what steps should be taken, if they are found not to be 100% safe. I feel sure that the people who use our areas would feel no qualms about drinking the water from these supplies, if this fact could be brought to their attention.

In conclusion, I should like to bring out the point that, while it is possible to operate our parks and forest recreational areas without all of the facilities described to you previously, we do not consider an area complete if it does not have drinking water available. In fact, it is the policy of the Department of Conservation not to open an area to public use until this facility has been supplied.

Discussion

Donald C. Calderwood (Nashua, N. H.). I think one of the main reasons why this paper will be of value to many of us is that, being water-works men, in any community we are more or less looked upon as experts in water-supply and water procurement programs. I know that often people from outlying districts come to the office and ask for assistance in obtaining an additional water supply or

obtaining a corrective measure for the water supply that they already have. The paper was presented to you with the thought in mind that these are small supplies, developed for a specific purpose, and that from this information you might get a hint as to how to solve a problem which may be presented to you by some of your townspeople or neighbors, and in that way you might be of assistance to the community. On behalf of the Association I want to thank Mr. Howard very much for the paper.

A MEMBER. I should like to ask Mr. Howard if there is any method which we can use to prohibit parks and reservations from bordering on public highways. In our town we have to run water mains up alongside the parks, with no revenue on one side of the street.

ARNOLD E. HOWARD. The only comment I can make is that the parks that we have at the present time—the ones, I think, to which you have reference—have been gifts to the Commonwealth, and when such things are given to us we do not like very well to turn them down.

THE MEMBER. Couldn't there be some method of keeping any park at least 200 ft from any public highway?

MR. HOWARD. You might get some legislation on it.

THE MEMBER. In our town they went and bought the land at $5 an acre.

MR. HOWARD. It would have to be by legislation, I should think. If you could get somebody to put in a bill to the legislature, that is the only way you can take care of it.

REFLECTIONS ON THE BAR HARBOR FIRE

BY THEODORE W. GRINDLE*

[*Read December 18, 1947.*]

THE reflections on the Bar Harbor fire are not pleasant memories to any of the residents of Mt. Desert Island, for everyone had either friends or relatives who suffered losses, from which many of them will never live long enough to recover. Some of them lost not only their homes and all personal property, but their jobs as well.

It is rather difficult to pick out any one part of the fire for a subject, such as a water company's ability to serve the fire department at such a time, which was originally suggested for this paper. There seems to be no one phase of the fire that would make a story within itself. Therefore, if I may, I shall generalize on the whole subject.

Needless to say, the Bar Harbor fire was a tremendous operation, involving hundreds of men and pieces of equipment, including pumpers, fire trucks, gas-tank trucks used for hauling water to strategic areas, bulldozers and large Diesel-powered road machines, etc. In order to realize its magnitude, it is necessary to drive over the area—not for one hour or half a day, but for an entire day, and then much of the burned area would be missed.

To start with, this fire burned 17,143 acres, comprising 55% of the total area of the town of Bar Harbor.

This fire started on the afternoon of October 17, 1947, in a large meadow on the northern end of Mt. Desert Island, and was undoubtedly the result of carelessness on the part of berry-pickers. It burned vigorously for the night of the 17th and was finally brought under control sometime during the day on October 18th. It was wholly confined to the marshland area in which it originated. The fire on this date burned over approximately 169 acres. For all intents and purposes, to the minds of the townspeople, it was extinguished and a forgotten incident.

The marshy area in which this fire started was apparently also

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of a peat-bog nature and, while the fire seemed completely extinguished, it must have been burning underground. On the morning of October 21st, with a high northwest wind blowing, the fire surfaced and started on its rampage, burning on this day 2,050 acres.

On October 22nd, it developed into two distinct fires—one to the north and one to the west of the previous day's burn. However, due to light winds, the fires made relatively slow progress. Both fires consumed on this day 2,228 acres.

On the morning of October 23rd, this fire, fanned by a southwest wind, made rapid progress toward the Hulls Cove area and thus was brought nearly to the shore in a northerly direction from town. Bar Harbor was then in dire peril, should the wind change into a north or northwest direction. All weather reports indicated that that was exactly what we might expect during the afternoon. The weatherman's prediction certainly came true. About 3:30 the wind came, not gradually, but by gale force, estimated to be in the vicinity of 50 miles per hour, and this fire started on its devastating path toward Bar Harbor and the sea. On this day, it burned 10,908 acres.

During October 24th, and through October 27th, the perimeter of the fire was still being fought and during this period it burned over another 1,788 acres.

For the next three weeks, or until November 14th, when the fire was officially declared out, the fire line, which had to be guarded and constantly worked on, was 24½ miles long. Incidentally, when this fire was finally extinguished, it was done with water. The National Park alone had eleven pumping stations, plus a destroyer anchored in Somes Sound, all getting water from sources other than the Water Company's system.

I assure you that it was a sight that made one realize how insignificant mankind is against the elements, with all his man-made machines. Such a fire could not, I believe, on its travelling front be stopped by any amount of water, being administered by any number of men.

Up to the afternoon of October 23rd, the Bar Harbor Water Co. had been of no material aid to the fire departments and fire-fighting crews, with the exception of one area in Hulls Cove, where men fighting the flank of the fire undoubtedly saved that locality with

water. Thus it is clearly shown that until such time as a forest fire reaches a water company's pipe lines it cannot hope to be of any material assistance, and then only when the fire is of such proportions that man can stand before it.

It was not until about four o'clock that any unusual draft on our system was felt, but from that time on the demand increased until our Venturi meter was taxed to its maximum reading of 5.6 mgd. I am unable to give you any further data on the consumption of water, other than the fact that the pressure chart at the Water Company's office, which registers normally 97 lb, dropped to 28 lb. However, it was gratifying to learn that from October 22nd to October 30th our source of supply, which is Eagle Lake, situated 276 ft above sea level, lowered 4⅜ in., and some of this loss naturally was due to evaporation.

It is difficult to paint an oral picture of the advance of this fire. It resembled in many ways a huge blow-torch, sending flames hundreds of feet into the air and ahead of the actual burning. The roaring of the fire was a sound never to to be forgotten. It reminded one of dozens of freight trains moving all at one time. This fire, at times, was travelling at least 10 miles per hour, especially on the higher elevations. I was told by many of the veterans who had seen active duty that, aside from the shooting, this fire was very much like the war and, in many instances, they much preferred the war to a conflagration such as this.

As the fire neared the village of Bar Harbor, the wind changed from the northwest to the north and thus placed the larger portion of the town on the flank of the fire. Had not this change in wind occurred, Bar Harbor most certainly would have been completely wiped out, in my opinion.

As I look back on the night of October 23rd, it seems more like a dream than an actuality, but each day, as I drive out and see the ruins, my mind suddenly goes back to the confusion of it all—the maze of telephone and electric-light poles and wires stretched everywhere, trees down and others constantly falling, blocking roads and driveways. It was necessary for my crew to carry axes, cross-cut saws and wire cutters and literally cut their way through to their work.

Due to the complete devastation, our work was made compara-

tively easy during the immediate crisis. As street after street was entirely leveled, we were enabled to isolate these areas by streets and thus save hundreds of thousands of gallons of water a day from being wasted—and do it quickly. Fortunately the people of the summer colony—most of them—had closed their homes for the season.

Since then, it has been necessary to pick up these services one by one. We have already closed 165 and nearly every one was owned by local people. I don't know how many times I have thanked God for the new electric and magnetic instruments used in locating pipe lines and boxes. Measurements were of no value, for all landmarks were gone.

The exact number of men fighting the blaze will never be known. However, we do know that the Army sent in about 300; the National Park Service flew in 40 trained forest-fire fighters, and the Navy and Coast Guard sent in a considerable force. There were 900 local men registered as fire fighters. Probably as many more were fighting, who never gave any thought to registering and compensation, but fought to save the town and their homes.

While this fire was at its peak, the local fire department, together with many other fire departments, had laid and was using approximately 26 miles of hose. This was scattered all over the territory, where they were pumping from ponds or any other source of water that was available. When a final count could be made, it was found that thousands of feet of hose were lost—just how many feet could not be ascertained. There were 14 separate fire departments active during the whole period. We do know that our town lost 11,000 ft of hose and the National Park's loss was 20,000 ft.

The evacuation started about 3:30 o'clock and was really something to witness. Literally hundreds of cars went slowly by—bumper to bumper—on their way to Ellsworth via Northeast Harbor. The main route out of Bar Harbor had already been cut off. Other hundreds of people, who had no cars, came plodding on foot to the Athletic Field with their most cherished belongings, only to be moved later to the dock area (a mile away), which at the time seemed safer and from which they could be taken by water to neighboring towns, should boats become available. A few did leave by boat and had a nasty time of it, due to high winds and seas.

By 4:30 this line of cars was stopped, as the fire had cut off all roads leading from Bar Harbor. Thus by necessity everybody left in town moved onto the dock or shore front. There were estimated to be some 2,500 people in cars, busses or on foot and there they witnessed probably the most spectacular sight it will ever be their lot to see—fires burning for a distance of eight miles from Hulls Cove to the Ocean Drive—hotels, large estates, and even Mt. Cadillac itself was all ablaze.

Traffic was extremely heavy and nerves were tense. Serious accidents occurred, taking the lives of two young people and hospitalizing many others. We were very fortunate that many more did not perish in the fire. Only one man died by burning, and only because he refused to leave his home when transportation was available.

At such a time, what few men are not fighting fire are disorganized as crews. Schools are discontinued and the sick evacuated from the hospitals.

Bar Harbor was immediately placed under partial military law and naturally it was more than your life was worth to move about. Passes were necessary, to get on or off the Island, and women and children were under curfew law at 6:00 P.M., unless accompanied by a male who had a pass. But regardless of the nuisance it seemed to be, it was necessary and the Bangor-Brewer National Guard did a fine job, property losses being held at a minimum.

The Bar Harbor Water Co. was indeed fortunate. We had no loss of property by fire. Why our pumping station still exists is a mystery. Our transformer block, about 50 ft distant, burned and tumbled into the street. This building is of wood construction, having asbestos shingles on both roof and sidewalls. The finish is of wood and the paint was well blistered in places.

The Water Company's revenue at the moment is certainly in a sad plight. Figures based on our 1947 business (which, perhaps, is not the basis on which to figure, as 1947 was the largest year the company had ever experienced) show that about 25% of our expected revenue for 1948 is non-existent. Certainly, we cannot hope to recover any great amount of this loss for at least two years, and from then on it will be a slow process, with building conditions and prices as they are today.

The same is true of the town. One and one-half million dollars of its taxable property was lost, or about 23% of the whole.

Many things happened during the conflagration, both amusing and tragic. In one instance, a woman, who hurriedly gathered a few things to evacuate, found on reaching Ellsworth that her purse was filled with clothespins. How they got there was a mystery, even to her. A man carefully guarded a preserve jar filled with split peas, while his $500 in another jar burned on the pantry shelf. Time will not permit me to enumerate the many stories of near-tragedy and comedy that occurred.

It is difficult to realize the condition of the men who fought the fire on the 23rd of October. Most of them had had no rest to speak of for three days and, before the fire was anywhere near its height, they could not speak above a whisper, and in some cases could not speak at all. This was due to laryngitis, caused by smoke inhalation for hours on end. They were fatigued to a point that is difficult to comprehend. It is amazing to me that, working under such conditions, they could organize a fire-fighting line on the flank of this fire a mile long and keep it from entering the village.

We must not be—and are not—pessimistic over the future of Bar Harbor. True, as you wander about and gaze upon the burned trees and shrubs and empty cellars, it is discouraging, but nature is a great healer. Once the dead trees and debris are cleared away and spring brings its new growth, we believe that many views heretofore undreamed of will compensate to a degree for the loss of our natural beauty.

I do not know how anyone can show enough appreciation at a time like this to the many friends who wrote letters, telephoned as often as possible, and even drove hundreds of miles to give aid and comfort. To those friends I wish at this time to extend my most sincere thanks.

The fire is now over and the work of reconstruction is the order of the day. I shall not bore you with the many movements afoot to speed this end, but, in closing, I shall simply say that we believe Bar Harbor will arise from the ashes a bigger and more beautiful playground for the nation.

FOREST-FIRE HAZARDS

BY RAYMOND E. RENDALL*

[*Read December 18, 1947.*]

FOREST-FIRE hazards are caused by either man or God. Man-made hazards can be reduced by proper forest management and through education to minimize human carelessness. Hazards which may develop from certain acts of God may be overcome by detection and prevention measures.

More than 90% of all forest fires are caused by man and are due to carelessness, such as smoking, brush burning, camp-fires, railroads and incendiarism.

Lightning, both dry and from wet storms, is a common cause of fires. Bolts striking tree growth and lodging in dry ground will cause a fire that will be quickly discovered but, when moisture conditions are heavy, fires may mull and burn in trees for days or weeks before there is any danger of spread. Such fires produce only a wisp of smoke that is hard to discern by lookout-tower men. They can be located by observers in airplanes, making flights soon after any lightning storm.

Epidemics of insects or disease, attacking forest growth and killing large areas of trees, occur periodically. Dead trees are always inflammable and the larger the number, the greater the hazard.

In 1938 all New England experienced a terrific hurricane, which uprooted trees in its path over thousands of acres. Although most of the merchantable growth in the blowdown was salvaged, even now much of the resultant debris remains as a hazard.

A final hazard over which man has no control is due to certain weather conditions, caused by lack of rainfall, extended periods of drought, continued high temperatures and high barometric pressures, together with strong winds.

Maine may well be called a forest state, for 84% of its land area is covered with forest growth. Because climate and soil conditions

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are not suited to other land use, Maine should continue to be a timber-producing state, as it has for the past 300 years.

Although fire laws were first enacted in 1855, it was not until 1891 that the office of Forest Commissioner was established. Organized forest-fire protection was provided by law in 1909 by the creation of the Maine Forestry District, which comprises the 10,000,000 acres of wild lands or unorganized townships of the state. Protection of the forest lands in the organized towns rests with the municipal officers. The state has been coöperating since 1918 in the erection, operation and maintenance of lookout towers, and since 1931 state wardens have assisted towns with personal services and the use of fire-fighting equipment. In 1945 the state aided further by establishing a fund with which to reimburse the towns one-half their forest-fire suppression costs.

Maine has enjoyed an enviable forest-fire record up to the present year, which was the first abnormal fire season in the history of the state. The spring season was normal, with an average of 5 in. of rain for the months of April, May and June. After the first week in July there started a continuous dry spell, unbroken up to the first week in November. Conditions became so dry by the middle of October that normal water levels in wells, streams, ponds and bogs dropped out of sight. Soil moisture disappeared. Down timber and slash, resulting from heavy cutting for the war effort and for post-war construction, were highly inflammable. The autumnal fall of leaves added a fuel which was not only ready to burn, but would blow long distances.

Fires were prevalent under such conditions but were kept under control until the high wind of October 23. Then the catastrophe occurred! A hundred fires were burning in every section of the state. Thousands of volunteers, with added equipment from outside sources, finally brought the fires under control and a few days later God-sent rains completely suppressed any remaining fire in the ground. Our loss was 250,000 acres of forest land and 1,200 homes, with an estimated damage of $30,000,000.

Without a doubt the public will now demand better forest-fire protection in the future. This will mean improved methods of detection and prevention, pre-suppression and suppression.

Better detection will call for an increase in the number of lookout towers, ground patrols, and the increased use of airplanes.

Better prevention will demand greater consideration of forest cutting practices, so as to insure a better conservation of soils and soil moisture. The relation between forests, water and wildlife has been virtually ignored. There has been a conflict between intensive management of forests for timber production and management for other uses. One of the essential uses of forests is watershed management for surface-water and ground-water reservoir recharge, as well as for maintenance of stream flow and for flood and erosion control.

Measurement of forest-fire danger will aid greatly in prevention and control, by increasing observations to determine soil moisture content and condition of vegetation. Compulsory lopping of slash will greatly reduce its fire hazard and fire prevention through education is all-important. It is very essential that patrol of fire lines be continued and maintained until rains have come.

Pre-suppression concerns the organization, training and instruction of men, and the maintenance of equipment and supplies, to insure effective fire suppression.

Suppression improvement will be brought about by better technique and the use of proper methods, together with the most effective equipment.

The New England Council has, for the last few years, sponsored a Conference of New England Forestry Officials. This Conference met last month and discussed the need of an over-all organization in New England, and within each individual state thereof, for the prevention and control of emergencies created by fires, floods and hurricanes. The Officials observed, during the recent forest-fire disasters, a lack of:

1. Adequate advance planning;
2. Coördination between state and municipal authorities;
3. Coördination between towns;
4. Centralized control or authority premised on law;
5. Forest-fire fighting equipment and supplies;
6. Trained manpower.

The Conference recommended, in part:

1. Forest-fire control activities in all New England states should be the responsibility of, and under the complete jurisdiction

of, the respective state forest agencies. Laws in each state should be enacted promptly to accomplish this end.

2. Each state and municipality should set up immediately a central authority, to coördinate the procurement and movement of men, supplies and equipment to affected areas.
3. New England and each state thereof should draw up a comprehensive forest-fire control plan. This plan should be prepared in consultation with a committee of representative citizens and should include the following:

A. *Procedures*

1. Fire-fighting squads of trained men appointed by the state forester should be organized.
2. A sufficient number of forest-fire weather stations should be established in each state. Daily readings should be taken at these stations and fire weather predictions sent from central headquarters to the wardens and to the general public.
3. Training schools should be held in each state, to educate and train supervisory personnel in forest-fire techniques. These men should educate and train local crews.

B. *Equipment*

1. All forest-land areas should have complete coverage by a network of lookout towers.
2. The entire area under protection should be covered by a complete, two-way radio network, linking patrolmen, towers, ranger headquarters, etc.
3. Airplanes should be used to supplement fire towers, principally in service work, such as guiding men to and on the fires, and transporting men, supplies and equipment to the scene of the fires.
4. Modern forest-fire fighting tools, especially portable power pumpers with plenty of hose, knapsack pumps, and all needed types of automotive equipment, such as pick-up trucks and boats with inboard and outboard motors, should be used.

C. *Education*

1. An increased and continuing program of education in forest-fire prevention should be carried out in the schools.
2. Public forest-fire prevention education should be carried on by newspapers and radio, and before groups and gatherings.

The adoption of such a program and the coördination of effort on the part of all will insure our New England against any future forest-fire catastrophe such as we had in October, 1947.

EXPERIENCES DURING THE RECENT FIRES IN YORK COUNTY, MAINE

BY LEANDER G. SMITH*

[*Read December 18, 1947.*]

To tell all the experiences during the recent fires would take far more time than has been allotted to me this afternoon.

There were two separate fires, or really three. The first one started on October 20th in the town of North Kennebunkport, five or six miles north of Kennebunk. It actually started on the 14th but had been kept under control until the afternoon of the 20th, when an 18-mph northwest wind caused it to break out again. By night it had fanned out and was racing for the coast, six miles away. During the next three days it had covered an area approximately six miles square. Before the fire was brought under control, 102 water takers in the Goose Rocks area and 58 in the Fortunes Rocks area had lost their cottages, and about 30 permanent homes were burned in Cape Porpoise. These figures include only the homes using water from our system. There were many more that burned in the outlying districts.

At first there was more or less confusion. The fire was spreading so fast that no one man or group of men could effectively direct the fire fighters from the fire area. Consequently, headquarters were set up at the Fire Station at Kennebunkport and, by having people stationed near telephones in various sections, help could be dispatched where the need was greatest. On the evening of the 22nd the Army came in with jeeps and two-way radios and took over the communications. As they were constantly patrolling the fire area, a call from them would soon have a pumper, followed by a trailer-truck with 3,000 or 4,000 gal of water, on the spot and many homes were saved through this method. Where all the pumpers and tank trucks came from I never expect to know, but there was always one on the spot, ready to go. Many times they would be transferred from one section to another without reporting back to headquarters, their orders hav-

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ing been changed by radio to the nearby jeep, the operator of which would deliver the message.

During all this time the Red Cross had set up Canteens, which were serving meals 24 hours a day. Trucks and autos were carrying sandwiches and coffee to the men on the fire lines. Sleeping quarters were set up in the Firemen's Hall and many of the men never saw their homes during the fire. There were several cases where men were fighting fire in one section, only to learn that their own homes were gone.

So much for the fire in the Kennebunkport area. By the 24th it had burned itself out or was mostly under control. While the fire was raging, we were hearing about a fire 25 miles northwest of Kennebunk, but little did we realize that it would ever reach our town. There had been a fire in the town of Newfield, on the New Hampshire line, for three days but it had been kept more or less under control until the 20th, when it broke out but was checked again above the town of Waterboro on the 22nd. A high wind on the 23rd caused it to break out of control and, during that day and the next, it travelled over 20 miles in a southeasterly direction, being stopped on the night of the 24th only 2½ miles from Kennebunk village. A light rain on the 25th gave the fire-fighters a chance to prevent its getting out of control again.

As in Kennebunkport, headquarters were set up in the fire station in Kennebunk and all operations were directed from there. Once again the jeeps with their radios proved of the greatest value. The Army, having been moved up from Kennebunkport, took over the patrol and police work. The Governor declared a state of emergency and it was impossible to move in the fire areas without proper credentials. The Disaster Committee of American Red Cross quickly set up headquarters and was serving meals 24 hours a day. Where all the food came from and who cooked it will never be known. It is estimated that 10,000 meals were served in the First Parish Unitarian Church. First-aid stations were set up and sleeping quarters were established at the High School and the Town Hall. The Principal of the High School took over the control of the moving vans from his office. At one time there must have been 25 trailer-vans in the school yard, ready to move furnishings, etc. Other trucks were constantly

bringing in furnishings from outlying districts, but most people lost everything, if their houses caught fire. Even the ashes were burned. In no place can you find a partly burned building or even a charred timber.

It was a terrible experience and no one wants to go through it again. The question is: what have we learned by it? We know now that there should always be a skeleton organization, to take over in case of such an emergency. But will we do it? I doubt it. Too many are already forgetting and are not willing to devote the necessary time to such a cause.

For the benefit of any of you who may have such an experience, I should like to point out a few things that seemed very important to me. If it appears to be developing into a major catastrophe, first establish headquarters, with competent men in charge to carry on. In case of fire, know where to call for help and the kind of help you will receive. If you are not on a substantial public water supply with hydrants, know where to procure tank-trucks and pumps to fill them from brooks or ponds. Establish a communication system. I believe the time is near when you will see two-way radio systems put to many uses. I am sure it would be a help many times in our own work, if we could call our own trucks in case of need.

Another valuable piece of equipment that was used with great success was the small oil-truck, that delivers oil to our houses. Such a truck is equipped with quite a powerful pump and, by disconnecting the meter and by-passing around it, it can deliver a powerful stream of water on a fire. These trucks carry several feet of hose and can get to places where heavier equipment could not go. They did wonderful work on this fire.

We can never say too much about the wonderful coöperation that was furnished. Men and equipment came in from miles away. I could spend hours telling of the work done by outside organizations. While many lost their homes and all they owned, no one went hungry or suffered for want of shelter or clothing.

Discussion

Donald C. Calderwood (Nashua, N. H.). Listening to these papers reminds me of what I was told by a teacher when I was a

youngster, to the effect that fire is man's greatest friend and servant when controlled, and man's greatest enemy when out of control. I believe, after listening to these papers, that you will agree with that statement, as it still holds true today.

ROGER W. ESTY (Danvers, Mass.). How much of a drag was made on your water system, Mr. Smith?

LEANDER G. SMITH. We were pumping a little more than 1 mgd for the fire, but it should be remembered that our system is a rather peculiar system. We have close to 100 miles of water main in the system. It starts about a mile inside the town of York and it ends near the tip end of Biddeford Pool. As nearly as anyone can measure, it is 30 miles from one end to the other. It takes in that whole coast. Our water mains were not large enough to supply the water that a fire of that kind had to have. There were three summer colonies afire there at one time and God only knows how many fire engines were trying to get water from the system. Our mains were not big enough to supply the water. I do not think any water company would ever be expected to build a system big enough to take care of things in such a case as that.

WILLIAM B. DUFFY (North Andover, Mass.). Do any of the speakers know anything about the rumors that we have all heard about incendiarism during the fires?

MR. SMITH. I do not have any evidence on that, but there was a lot of talk about it during the fire. Frankly, I am almost willing to say I do not believe any of it. When you have a fire a quarter of a mile away from you and, the first thing you know, you have it burst right over your head, and then see it a quarter of a mile beyond you—that I saw happen—why, it is a question whether you would ever have anyone try to set it. I think the fires all came from flaming boughs and leaves, and so forth.

RAYMOND E. RENDALL (Augusta, Me.). I should like to say just a word in connection with what Mr. Smith has said. Practically all the fires that were burning during the week of the big wind had been burning anywhere from two days to a week prior to the days of the wind. We did have a lot of pyromaniacs in the area during the time the fires were raging, and I think there is no doubt they were setting fires. In fact, we caught, I believe, at least six that were put in jail.

So that those were in the picture, the set fires. Those fires came within the area of the big burning. In the York County area of 100,000 acres there were 1,200 homes burned, and the damage has been estimated there at some $30,000,000. But the important thing is that all the fires were burning and, had the fire in Wakefield, N. H., been patrolled, it could have been held in New Hampshire. The same applies to the other fires. In other words, they would have been confined to the local areas where they began.

MR. CALDERWOOD. This whole program today is somewhat off the beaten path of a meeting of water-works men, but I feel that we are all going to take home some very worth-while things. Those of us who have large areas of forest land in connection with our water supplies, I am sure, will feel that there is a very definite connection between forest fires, forest areas and water supply.

A PRELIMINARY REPORT ON SANITARY ENGINEERING ASPECTS OF NATIONAL SECURITY

SUBMITTED BY THE SUBCOMMITTEE ON
SANITARY ENGINEERING ASPECTS OF MAJOR CATASTROPHES
NOVEMBER 4, 1947

Prepared for and at the Request of the
Committee on Sanitary Engineering and Environment of the Division of
Medical Sciences, National Research Council

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INTRODUCTION

This report deals with some of the sanitary engineering aspects of major catastrophes primarily as affecting the civilian population. It presents statistical data concerning catastrophes during the last quarter of a century resulting from natural phenomena and man-

made causes. It gives emphasis to the special hazards of the future in the light of technological developments in the arts of peace and war and recommends organization of sanitary engineering services to mitigate the effect of future catastrophes and to provide for control and relief measures when they do occur.

The subcommittee feels that under present world conditions it would be entirely unrealistic to assume that future wars could be avoided. Therefore, in its consideration of the hazards of major catastrophes it has taken into account the possibility of war and considered the broad phases of national security.

The cushion of time and distance which in previous wars made it possible for this nation to delay in organizing programs of civilian defense no longer exists. The potentialities of atomic and bacterial warfare and of well planned sabotage must be given realistic consideration in our plans. Through such measures an enemy nation might seriously attack our war resources in materials, production, transportation and manpower. Such an attack would affect areas of our civilian economy in which the sanitary engineer has a direct responsibility and where his special training qualifies him to serve in a program of defense or prevention.

We must make adequate preparations for meeting the emergency sanitary engineering problems associated with natural catastrophes; in addition it is necessary to develop an organization capable of orientation to the contingency of war, while functioning efficiently in times of peace.

Sanitary Engineering Aspects of National Security

A well coördinated program of national security to safeguard public health, welfare and our economic potential should include a plan and organization for sanitary engineering activities. Sanitary engineering applies particularly to protection and promotion of public health through control measures over the environment in which people live and work. This specialized service and responsibility includes such essential community or regional facilities or services as: water supply, sewerage, control over atmospheric and stream pollution, insect and rodent control, sanitation of food production, processing

and distribution, garbage and refuse collection and disposal, sanitation as related to housing, industry, ventilation, swimming and bathing and general community life, and related matters.

Natural phenomena and technological advances, both for war and peacetime pursuits, have profound and serious influences on the public health and safety aspects of man's environment. They are factors which the alert sanitary engineer must take into consideration in meeting his public responsibilities—factors concerning which he should be informed if he is to discharge this responsibility.

The economic prostration of England last winter resulting from a succession of snowstorms, high winds and floods; the widespread floods this spring in the Missouri and Mississippi river valleys; and the Texas City explosion are recent examples of the types of disasters in which civilian populations were exposed to extreme hazards and emergency situations in which the services of trained sanitary engineers were essential in protecting life and property and preventing the spread of disease.

Special sanitary engineering skills are required to control insect and animal vectors of disease, such as the mosquito, the fly, the flea, the tick or the rodent; water supply is a prime essential to normal community life and a *must* in all basic industrial operations; through accident or sabotage of a public water system mass infection or poisoning of people may possibly be brought about; inadequate means of disposal of sewage or industrial wastes may result in gross pollution of public water supplies; atmospheric pollution may affect humans, animals and plants and may even render sections uninhabitable; areas of inadequate and insanitary housing are places where economic inefficiencies exist, high disease rates flourish and crime breeds; in the wake of great disasters problems of sanitation and rehabilitation remain to be resolved.

Classification of Hazards

Hazards to civilians may be the results of natural phenomena, man-made accidents or those resulting from war activities. The following are various types of hazards with which the sanitary engineer is especially concerned, at least in some phases:

Natural Phenomena	*Man-Made Accidents*	*War Hazards*
Floods	Explosions	Aerial warfare
Cloudbursts	Wrecks	Atomic bombing
Tidal Waves	Fires	Radioactive Dusts
Seiches	Epidemics	Bacterial warfare
Hurricanes	Structural Failures	Poisonous warfare
Tornadoes	Spills	Sabotage
Typhoons	Poisoning	Destruction or deterioration of Essential Civilian Facilities
Earthquakes	Toxic Gases	Overdraft of Resources
Hailstorms		Curtailment of Production
Snowstorms		Curtailment of Transportation
Electric Storms		Diversion of Manpower
Duststorms		
Drought		
Temperature Excesses		
Prolonged Sunshine		
Humidity Excesses		
Surface Ice		
Frazil Ice		
Perma Frost		

This listing admittedly incomplete serves to show the extent to which the sanitary engineering aspects of civilian life in war or peace can be affected by hazards which may disturb or destroy our way of life. In time of war, man-made or accidental hazards, when superimposed on the hazards of war, could produce extreme catastrophes.

The Disaster Record

The American Red Cross has compiled statistics as to the number and type of disaster relief operations it has participated in in the 26 years, July 1, 1920, through June 30, 1946. These statistics cover operations in the 48 states of the Union, the District of Columbia and

the Territory of Alaska. Disaster relief operations are classified as follows:

Hurricanes	Floods
Tornadoes	All Fires, Including Forest Fires
All Other Storms	All Other Disasters

Data are not given as to the number of persons killed, injured or assisted in each of these disasters nor as to the property damage. However, some idea of the magnitude of the American Red Cross operations may be obtained from the fact that during these 26 years the total expenditure for domestic relief operations was in excess of $105,500,000.

Statistical data on major disasters in which the American Red Cross participated during the years 1927-47 are given in Table No. 1 of the Appendix to this report. A listing of 38 major disasters in the United States covering the period 1865 to 1945 and classified as to types is given in Table No. 2. The total of deaths involved in these disasters is 29,622. Of further interest is the summary and classification prepared by the Metropolitan Life Insurance Company of 919 catastrophic accidents involving 12,987 deaths during the 10 year period, 1937-46, and given in Table No. 3.

Operations of the American Red Cross in the 26-year period, 1920-46, totalled 3,514. Adjusting for disasters which affected more than one state its net disaster operations were 3,146. They are summarized by regions and periods in Table No. 4.

Of special interest is the increasing rate at which these disasters occurred in the different periods. This may to some extent be due to the expanded facilities of the Red Cross with which to serve. The five year period, 1940-45, includes World War II when the strain of war was heavy and the frequency of extreme natural phenomena less than in the previous two decades. This is indicated by comparisons of total and natural disasters given in Table No. 5.

The term "natural disaster" is used to include those disasters classified by the American Red Cross as "floods, hurricanes, tornadoes and all other destructive storms such as hail, sleet, dust gales, bliz-

zards, etc." Such natural phenomena as earthquakes and droughts are listed under the classification as "all other relief operations" and to the extent that they occurred the actual number of reported natural disasters would be greater. In Table No. 6 these natural disasters are summarized by type for each of the three periods constituting the 26 years, 1920-46.

In the twenty-six years the Red Cross has participated in disaster relief of some kind in all of the states ranging from seven instances in Delaware to 229 in Texas where on an average there has been one disaster every six weeks for the period. In thirteen states in which about 45 per cent of the nation now resides, the Red Cross participated in a total of 1,791 disaster relief actions or 51.9 per cent of their total operations during the period. Of these, 1,141 or 62.6 per cent, were disasters classified as natural disasters. See Table No. 7.

These states where the high percentages of disasters were of natural origin were in the south and southwest, while the low percentages of natural disasters were in New York, Pennsylvania, California and Illinois. These four states were among the six in which more than 50 man-made disasters and accidents occurred—especially fires—as shown in Table No. 7.

In Pennsylvania, New York, California, Massachusetts, Illinois and New Jersey there was a total of 417 disaster relief operations or 43 per cent of all disasters due to various types of fire. (See Table No. 8.) These are the great industrial states of the nation. Each has also experienced severe disasters due to natural phenomena such as floods, cloud-bursts and hurricanes, but they have not been stricken by hurricanes and tornadoes as often as the southern and southwestern states.

Agencies Organized for Disaster Relief

1. *American Red Cross.* The American National Red Cross, chartered under the Act of Congress approved January 5, 1905, among other things is charged with providing "a system of national and international relief in time of peace and to apply the same in mitigating sufferings caused by pestilence, famine, fire, flood and other great national calamities and to devise measures for preventing the same." Its relief work in the various states is carried out under

national direction through its nation-wide organization of local chapters. The Red Cross does not assume responsibility for governmental functions—federal, state or local—but when requested to do so assists and supports such units of government or their constituents. It has been very effective in obtaining and coordinating assistance from federal sources such as the Army, the Navy, the Coast Guard, the Public Health Service, the Weather Bureau and other units of the federal executive departments and agencies with state and local relief work in stricken areas.

In matters of sanitary engineering, which are myriad in disaster relief work, the Red Cross works primarily through the United States Public Health Service at the federal level; and the respective state and local Departments of Health at these levels. It has no full-time sanitary engineer on its staff although from time to time the employment of a sanitary engineer has been considered. It is difficult to see how the Red Cross can expect to continue fully to discharge its responsibilities unless such an important factor in disaster relief as sanitary engineering is more adequately covered. Full-time staff representation to direct field activities in sanitary engineering during periods of disaster and to assist and advise in planning policies and programs between calamities is needed in this organization. The Red Cross spends no funds for sanitary engineering work such as that of training engineers in disaster relief measures, studying the significant sanitary engineering features of past disasters, or maintaining current liaison with public and private agencies which are developing methods and products which might have a profound effect on the sanitary engineering aspects of future calamities affecting civilians. In previous disasters the Red Cross has purchased or donated supplies needed in carrying out sanitary engineering control measures when local funds or facilities were not available; and it has obtained the assistance of other federal and state agencies when requested to do so.

2. *Public Health Service.* The Sanitary Engineering Division of the Public Health Service, working through the Conference of State Sanitary Engineers, and through its regional engineers, maintains an effective liaison with state and local sanitary engineers. It has responded to calls from the Red Cross and the states in many emergency relief operations, whether disaster or epidemic. Through its

ability to mobilize engineers and to develop coöperative programs for prompt action in the field it has been especially effective in disaster relief work. But between disasters the Public Health Service engineers return to their normal assignments. Accordingly the full value and advantage which could be derived from study of the sanitary engineering lessons from past disasters is not obtained; and background is lacking against which to investigate and appraise the hazards of new developments which might affect or be affected by future calamities.

3. *Office of Civilian Defense.* By Executive Order 8757 of May 20, 1941, the Office of Civilian Defense was established in the Office for Emergency Management to assure effective coördination of federal relations with state and local governments engaged in the furtherance of war programs. Its sanitary engineering programs were under the direction of commissioned engineering officers of the Public Health Service. Much was accomplished in stimulating state and local officials to organize effective defense measures against the hazards of war, especially in protecting public facilities against possible bombing and sabotage. As a result of O.C.D. activities, many states which never had official plans for disaster relief developed them, while others revised and strengthened plans which previously existed. The O.C.D. maintained effective liaison with officials in charge of war production, and with the military forces, and continued to alert state and local officials to real or potential hazards in their area. It assisted in developing coöperative programs to train sanitary engineers in special war work and to keep them informed of new developments and methods which deserved consideration in the national defense program. This Office was abolished as of July 1, 1945, but the benefits of its training program with sanitary engineers has not been lost entirely as these men are well dispersed in public and private agencies. Under proper organization and direction they could be recruited to serve again in emergency reserve units.

4. *State Organizations.* In many of the states and some large cities which have experienced serious disasters in the past, emergency plans and organizations exist through which prompt relief actions could be taken in case of emergency. These would be activated if the governor or the mayor were to declare a state of emer-

gency at which time funds especially appropriated could be used to finance operations. In the states of California, New York, Illinois and Massachusetts such emergency plans and programs have been well developed. State emergency organizations when fully developed can be especially effective in the field of sanitary engineering where prompt and intelligent action is essential to prevent epidemics. There is the advantage of working through established agencies and with personnel who are well acquainted with local conditions and methods.

From the standpoint of national security it is important that the programs and policies of these state emergency organizations be coördinated with a national plan. The period between disasters should be used to appraise the effectiveness of field activities carried out during previous disasters and to plan improvements in methods, equipment and training of personnel. To do this on a national basis would require centralization of policy and programs through an agency at the federal level where direction of new research and development programs affecting the national economy and security usually rests.

Disasters of the Future

In the light of past experiences and current knowledge as to the rate of technological advances in industry and methods of warfare it is possible that the hazards which lie ahead of us as a nation may exceed our present ability to visualize them. They may be classified as hazards of war production, hazards of direct warfare and hazards of sabotage. It is conceivable that these could occur simultaneously with one or more of the natural or man-made hazards of past experience. By planned control measures and by alertness in preventive measures the damage resulting from such catastrophes may be materially lessened.

Any new products which are today in the research or pilot production stage may, when manufactured in large quantities, result in waste to the atmosphere or to waterways which would be extremely costly or hazardous. All too often in the past, communities have been exposed to hazards and blight by the waste products of some new industry or by changes in operations of an existing industry.

Who would have suspected that the waste products from a plant producing the newly discovered penicillin, when discharged to a sewer,

would disrupt the biological processes depended upon for treatment of sewage? This actually happened at Ley Creek Sewage Plant near Syracuse, New York. Who knows to what extent radioactive dusts from new atomic energy plants may pollute the atmosphere, the water stored in open reservoirs of public water systems, or the streams from which a water supply is obtained?

Wastes from oil or ore refineries, canning and packing plants, tanneries or plants manufacturing synthetic rubber, explosives, by-products from coal, rayon, plastics, resins, food products, biologics, and radioactive products of nuclear fission when discharged to the atmosphere, to waterways or even to public sewers could create severe hazards to plant employees and to the communities in which they live.

Public Facilities. Most large chemical and war production plants are dependent on enormous volumes of water for processing and on power for operation. Unless such plants are located where these utility services are available on a firm basis, production may be stopped or seriously curtailed when the products are needed the most. A prolonged drought, a dam failure, or excessive pumping from underground water sources may change the service capacity of a normally firm water system to one which cannot meet even the minimum sanitary needs of the people it serves.

Cities which, for one reason or other, may be called upon to provide special services in utilities, housing, transportation or policing in time of war should be reasonably forewarned so that they can plan accordingly. Currently the proposed expansion of public water and sewer systems throughout the nation is estimated to be in excess of $4,500,000,000. If the proposed structures and facilities would be vulnerable to damage by new weapons of warfare, these facts should be taken into consideration *before* the works are built. It may be desirable that the designs should be changed to give the best possible protection. In water supply systems, for example, many structures such as tunnels, transmission mains, filtration plants and feeder mains are built with a life expectancy of 75 to 100 years. This nation has a very great stake in the ability of its cities and communities to carry their responsibilities in time of war. From the standpoint of national security, everything possible should be done to insure that the loca-

tion, size and type of these public works projects be in the best interests of the nation.

Chicago, the greatest railroad center of the country, and one of the most important war production cities of the nation, is considering an expenditure of $60,000,000 for a new water filtration plant. It will have an intake in Lake Michigan and new supply tunnels and will serve two-thirds of the city. To what extent is the city in its decisions concerning the location and design features of this plant, considering the national security in relation to potential war damage to this important plant? In the extensive planning for water supply to serve its citizens and the great naval base, to what extent have the officials of San Diego, California, been advised of, and to what extent are they taking into account, the Navy's possible future expansion of facilities in that city? Proper consideration of factors involved in the answers to these questions may well be of basic importance.

In wars of the future, the vast systems of open surface reservoirs, by which such cities as New York, Pittsburgh, Boston, Seattle, Tacoma, San Francisco, Los Angeles, San Diego and many others are supplied with water, may conceivably be exposed to pollution by radioactive dusts or contamination by materials used in bacterial or biologic warfare. To what extent do the officials in charge of these works have knowledge of what could be done to safeguard .the health and safety of the millions of consumers and hundreds of thousands of plants which are dependent on these water systems for service?

Sabotage. The fact that vital public works of this nation, on which our war potential rests, are vulnerable to some extent to sabotage is no secret. In the field of environmental sanitation the opportunities for sabotage are numerous, though generally limited in effective scope. Disruption of production by striking vital public facilities or operating units, releasing toxic gases, or by using poisons, bacteria, biologicals and radioactive substances is possible, at least theoretically, and might create sanitary engineering hazards. There is need for sound and continued study of the sanitary engineering aspects of our national security, for these are but a few examples of problems involving sanitary engineering.

Organizing for Disasters in Peace or War

Calamities due to natural phenomena or man-made accidents, or those resulting from acts of warfare, such as direct enemy attack or sabotage, involve a wide range of sanitary engineering problems. A consideration of these basic factors indicates that planning for prevention and control over major disasters should originate at a high federal level and be worked out in such detail as to reach down to each community in the nation. The policies, procedures and organization for carrying out the work should be such as to provide for efficient and effective operation in times of peace or war and to permit a rapid transition to meet circumstances. At the federal level the prime responsibility for developing programs and policies to prevent major disasters and to see that prompt remedial and relief actions are taken when they do occur should rest in the National Security Council recently authorized by the Congress. At the state level corollary relief actions in accordance with a well integrated national program should be taken under the emergency powers of the respective governors, authorized by proper enabling legislation. State funds, supplemented by American Red Cross and federal emergency funds, when necessary, are a prerequisite.

Sanitary Engineering Recommendations

1. Considering the importance of environmental sanitation in disaster relief work and national security, the committee recommends that special provision be made to develop sanitary engineering programs within the national disaster relief and security program and to place responsibility for them in qualified sanitary engineers. Currently there are numerous federal, state, local and even private agencies carrying out programs and research work having special relationship to environmental sanitation and, therefore, of concern to sanitary engineers. There is need for coördination of this work so that there may be a free exchange of information and experiences, elimination of any unnecessary duplication, and integration of effort for maximum usefulness in case of major disaster in peace or war. The necessity of secrecy in certain types of research and development work is recognized, but this should not be carried to such an extent

as to exclude considerations of potential hazards to man and his environment involving sanitary engineering matters.

2. The committee recommends that, in all research and development work of the federal government, channels be established through which the point of view of the sanitary engineer may be obtained. This may be done through employment of qualified consultants or the appointment of one or more full-time sanitary engineers on the staff of the agency or agencies concerned. Agencies in particular need of the full-time services of sanitary engineers are:

American Red Cross
Atomic Energy Commission
National Security Resources Board
Central Intelligence Agency

3. The Sanitary Engineering Division of the Public Health Service, by reason of its specially trained staff and established relationship with the sanitary engineering divisions of state, county and local departments of health, is particularly well qualified to serve as a liaison unit between federal agencies and those of the respective states and their instrumentalities. Its experiences through the loan of staff members to the Office of Civilian Defense during World War II should be of special value in developing new programs for sanitary engineering activities at federal and local levels, including recruitment and training of personnel.

4. The committee recommends that a permanent sanitary engineering unit should be organized in the Public Health Service to carry out disaster and national security activities.

Working with the National Security Council, Central Intelligence Agency, National Security Resources Board, the National Military Establishment, the American Red Cross and various other federal, state and local agencies, this unit would perform such functions as:

a. Coördinate sanitary engineering work between federal, state and local agencies, with special emphasis on mitigation of hazards to civilians in times of peace or war.
b. Develop plans in consultation with an over-all agency, for the organization and mobilization of sanitary engineers, water works operators and related manpower for service in local, regional or national emergencies.

c. Promote civilian defense and disaster-relief planning, involving sanitary engineering and environmental sanitation, through the Chief Sanitary Engineers of the state departments of health.
d. Develop a system of liaison and intelligence whereby in the location, design, construction and operation of public facilities the interests of national security are taken into adequate consideration.
e. Alert state and local agencies of such national defense programs as are likely to affect community resources or facilities for which they are responsible.
f. Develop training programs in environmental sanitation for professional and sub-professional people in order to establish a reservoir of trained personnel for service in times of disorder.

APPENDIX

TABLE 1.—STATISTICAL SUMMARY DATA ON SELECTED MAJOR DISASTERS, 1927-47, IN WHICH AMERICAN RED CROSS PARTICIPATED

Disaster	Year	No. of Persons		Buildings		Total ARC Relief Expenditures
		Killed	Injured	Destroyed	Damaged	
Man-made Disasters						
Texas City Explosion	1947	550	3,500	147	1,291	$1,426,750*
Hartford, Conn. Circus Fire	1944	168	654	—	—	90,164
Railroad Wreck—Lumberton, N. C.	1943	72	123	—	—	1,668
Natural Disasters						
Oklahoma-Texas Tornadoes	1947	165	1,017	2,709	2,345	1,322,873*
Hawaiian Tidal Wave	1946	159	248	712	1,260	416,441
Southern New York Floods	1946	5	40	261	6,022	368,087
North Atlantic Hurricane	1944	48	351	2,666	41,943	237,672
Ohio Valley Flood	1945	24	852	1,401	37,414	849,785
Midwest Floods—6 States	1944	36	120	3,544	18,312	295,445
Midwest Tornadoes—7 States	1944	76	559	3,041	2,958	180,629
Maryland, Ohio, Pennsylvania and West Virginia Tornadoes	1944	107	412	678	559	445,475
Midwest Floods—8 States	1943	46	94	5,020	32,341	1,056,860
New England Flood	1927	45	27	1,368	2,346	1,299,774
St. Louis, Missouri, Tornado	1927	76	1,500	5,000		1,017,330
Florida Hurricane	1928	1,810	1,849	9,860	22,554	2,702,463
Mississippi Valley Flood—7 States	1927	246	†	41,487	180,507	16,994,868
Drought	1930-32	—	—	—	—	13,161,696
New York-New England Hurricane and Floods	1938	494	708	4,500	15,139	1,682,000
Ohio-Mississippi Valley Floods—14 States	1937	137	544	12,860	60,792	25,565,680
Midwest Floods—17 States	1936	107	306	4,498	30,354	6,178,106
Midwest Tornadoes—6 States	1936	352	2,215	2,054	1,824	874,858

*Budget estimate.
†Unavailable.

TABLE 2.—MAJOR DISASTERS* IN THE UNITED STATES
(From the 1947 Edition of *Accident Facts*, National Safety Council)

Type	Disaster	Date	Deaths
Fires:			
	Peshtigo (Wisc.) and surrounding area forest fire	10-9-1871	1,152
	City of Chicago	10-9-1871	107
	Iroquois Theatre, Chicago	12-30-03	575
	Cleveland Clinic	5-15-29	125
	Ohio Penitentiary, Columbus	4-21-30	320
	Dance Hall, Natchez, Mississippi	4-23-40	208
	Boston Night Club	11-28-42	492
	Hartford (Conn.) Circus	7-6-44	168
	Atlanta Hotel	12-7-46	119
Marine:			
	Sultana exploded—Mississippi River	4-27-1865	1,405
	General Slocum burned—East River	6-24-04	1,021
	Titanic struck iceberg—Atlantic Ocean	4-15-12	1,517
	Eastland capsized—Chicago River	7-24-15	812
	Vestris foundered off Virginia Capes	11-12-28	111
	Morro-Castle burned—off New Jersey Coast	9-8-34	134
Floods:			
	Johnstown (Pa.)	5-31-1889	2,209
	Galveston tidal wave	9-8-00	6,000
	Ohio and Indiana	3-28-13	732
	St. Francis (Calif.) dam burst	3-13-28	450
	Ohio and Mississippi River Valleys	1-22-37	360
	Los Angeles	3-2-38	181
Storms:			
	Texas Coast hurricane	8-16-15	375
	Louisiana hurricane	9-29-15	500
	Illinois tornado	3-18-25	606
	Gulf Coast (Fla., Ala., Miss.) hurricane	9-17 - 18-26	372
	Florida hurricane	9-12 - 17-28	1,180
	Florida hurricane	9-1 - 2-35	500
	Miss., Ala. and Ga. tornadoes	4-2 - 7-36	402
	New England hurricane	9-21-38	682
	Ill., Tenn., Ky., Ala., Miss., Ind. and Mo. tornadoes	3-17-42	111
	Oklahoma tornadoes	Apr.-June, 1942	100
	Pa., W. Va., and Md. tornadoes	6-23-44	159
	Oklahoma, Missouri and Arkansas tornado	4-12 - 13-45	119
Others:			
	San Francisco earthquake and fire	4-18-06	452
	Long Beach (Calif.) earthquake	3-10-33	120
	New London (Texas) school explosion	3-18-37	294
	Port Chicago (Calif.) ship explosion	7-18-44	322
	Cleveland gas tank explosion	10-20-44	130

*Source: National Almanac, World Almanac, Texas Inspection Bureau, City and State Boards of Health, and the Metropolitan Life Insurance Company.

TABLE 3.—NUMBER OF CATASTROPHIC ACCIDENTS AND NUMBER OF LIVES LOST BY TYPE OF ACCIDENT—UNITED STATES, 1937-46*

Type of Accident	Accidents Number	Accidents Per Cent of Total	Deaths (Number)
Motor Vehicles	270	29.4	1,829
Conflagrations, burns, explosions	265	28.8	3,968
Air Transportation	63	6.9	787
Water Transportation	73	7.9	860
Mines and Quarries	62	6.7	1,136
Railroad (other than motor-vehicle collision)	46	5.0	818
Tornadoes, Floods, Hurricanes, etc.	96	10.5	3,137
Building Scaffolding, etc., Collapses	8	.9	92
Ingestion of Alcoholic Beverage Substitutes	7	.8	58
Food Poisoning	5	.5	75
Asphyxiation by Gas	8	.9	45
All Other	16	1.7	182
Total All Types	919	100.0	12,987

*Source: Statistical Bulletin—Metropolitan Life Insurance Co., Vol. 28, No. 3, March, 1947.

TABLE 4.—DISASTER RELIEF OPERATIONS PARTICIPATED IN BY AMERICAN RED CROSS, 1920-46

A.R.C. Area	States Dist.	1920-40	1940-45	1946	Total 1920-46	% of Total	Average Per Year
North Atlantic	9	213	137	73	432	13.4	17
Eastern	8	337	227	56	620	19.7	24
Southeastern	8	451	182	45	678	21.5	26
Midwestern	17	681	375	76	1,132	36.1	43
Pacific	8	155	108	30	293	9.3	11
Total	50	1,837	1,029	280	3,146	100.0	121
Average per year		92	206	280	121		

TABLE 5.—COMPARISON OF TOTAL AND NATURAL DISASTERS IN WHICH AMERICAN RED CROSS PARTICIPATED, 1920-46

Period	No. of Total Disasters	Natural Disasters Number	Natural Disasters Per Cent
1920-1940	1,837	1,207	65.5
1940-1945	1,029	468	45.5
1946	280	86	30.6
Total	3,146	1,761	55.9

TABLE 6.—NATURAL DISASTERS BY TYPE AND PERIOD IN WHICH AMERICAN RED CROSS PARTICIPATED, 1920-46

Type Disaster	Number			Total	Per Cent
	1920-40	1940-45	1946	1920-46	
Hurricanes	21	11	2	34	1.9
Tornadoes	618	191	36	845	47.9
All Other Storms	136	52	10	198	11.2
Floods	432	214	38	684	38.7
Total	1,207	468	86	1,761	
Average per year	60	94	86	69	

TABLE 7.—STATES HAVING 100 OR MORE DISASTERS—1920-46
(Where Organized Relief was Rendered by American Red Cross)

State	Number of Relief Operations		Per Cent Natural
	All Types of Disaster	Natural Disasters	
Texas	229	208	90.7
Pennsylvania	181	50	36.3
Mississippi	141	120	85.1
New York	140	38	27.1
Illinois	139	60	43.1
Oklahoma	139	118	84.7
California	137	38	27.7
Kentucky	119	771	59.5
Alabama	116	95	81.7
Ohio	115	70	60.7
Louisiana	114	100	87.8
Missouri	113	91	80.5
Georgia	108	82	76.0
Total	1,791	1,141	62.6

TABLE 8.—STATES OF DISASTERS RESULTING FROM FIRE, INCLUDING FOREST FIRES, 1920-46

State	Number of Disasters
Pennsylvania	91
New York	84
California	76
Massachusetts	61
Illinois	54
New Jersey	51

PROCEEDINGS

February 1948 Meeting

Hotel Statler, Boston, Mass.

Thursday, February 19, 1948

President Donald C. Calderwood in the Chair.

The President called upon E. Sherman Chase, Chairman of the Committee on Reciprocal Relations with the Institution of Water Engineers, to present an award of the Institution.

E. Sherman Chase. Mr. President and fellow members: This Association appointed a committee in 1939, entitled Committee on Reciprocal Relations with the Institution of Water Engineers. This committee consisted of Leland Carlton, Percy Shaw and myself. In coöperation with a corresponding committee of the Institution of Water Engineers, a mutual agreement was entered into whereby the two associations would exchange from time to time papers which, in the opinion of the respective associations, were worthy of special consideration. The agreement involved the award of a diploma by the association whose turn it was to make the award for such of the exchange papers as the awarding association deemed worthy of special consideration. This agreement, as I have said, was consummated in 1939, the year in which World War II broke out. As a result the activation of the agreement was postponed. But last year the Institution of Water Engineers revived the agreement and requested your committee to submit to it such papers, presented to this Association during the past four or five years, as the committee felt worthy of the award. The committee submitted to the Institution of Water Engineers some four or five papers which in recent years had received the Dexter Brackett Medal. It is gratifying that the Institution of Water Engineers selected as the paper for its award the one paper on which your committee had unanimously agreed itself as the one being most worthy of recognition.

As a result, a few weeks ago the Institution transmitted to us this first diploma, agreed upon by the arrangement made back in 1939, and, inasmuch as this is in a way an historical event and this is the first diploma to be awarded, I think it may not be amiss for me to read the citation. You of course know who the recipient is and, as a matter of fact, as far as introduction to you is concerned, no introduction is necessary. On the other hand, the wording of the diploma will be of particular interest to you all.

THE INSTITUTION OF WATER ENGINEERS OF GREAT BRITAIN

This diploma, for the period 1943 to 1946, has been awarded by the Institution to Gordon M. Fair of the New England Water Works Association of the United States of America, in recognition of the merits of his paper on "Hydraulic Investigation of Water Distribution Systems" which has been published in the Journal of the Association and will be reproduced in the Journal of the Institution. This award is also a token of the high esteem of the Institution for the work of the Association in promoting the advancement of water engineering. The seal of the Institution was hereto affixed on the third day of December, 1947, in the presence of B. L. McMillan, president, A. T. Hobbs, secretary.

On behalf of the Institution of Water Engineers and with the greatest personal pleasure, I hereby present you, Gordon, with this token of the recognition of the Institution of Water Engineers.

GORDON M. FAIR. This, Mr. Chase, Mr. President and fellow members of the New England Water Works Association, is to me a time to keep. Have I not received from the hands of an old and valued friend, and through the medium of my favorite professional society, the diploma of a proud institution in the nation from which I sprang? Need I labor the sincerity of my appreciation of this award? Do not the circumstances speak sufficiently eloquently by themselves? Rather would I, therefore, take this occasion to congratulate the New England Water Works Association and its guiding members, Messrs. Chase and Shaw and Carlton, on the genesis of this award, not because it recognizes the contributions of the individual to the dissemination of knowledge within a particular field but because it presents evidence of the good will that can be engendered between kindred men in sovereign nations—good will that has

its source in mutual interests and that draws its strength from common high regard. Events such as this, to be sure, are but small tokens of our progress in a troubled world, but you, Mr. Chase, and you gentlemen of the New England Water Works Association can be proud of your accomplishment as an association that is evident in the proceedings of this hour. As for myself, I accept this diploma with a very deep sense of pleasure and of gratitude. To me it is more to be desired than gold—yea, than much fine gold. I feel fortunate indeed that I can express to you all my thanks by word of mouth. To the Institution of Water Engineers I shall not fail to do so very promptly by letter. I thank you.

Secretary Knox announced the election of the following new members:

Members: Alfred W. Albert, Student, Harvard Graduate School of Engineering, Cambridge, Mass.; Elmer W. Campbell, Director, Division of Sanitary Engineering, Department of Health and Welfare, Augusta, Me.; Ray L. Derby, Principal Sanitary Engineer, Los Angeles Department of Water and Power, Los Angeles, Cal.; Roger P. Disken, Sanitary Engineer, Cambridge, Mass.; Samuel Jacobson, Chemist and Bacteriologist, New Haven Water Co., New Haven, Conn.; George M. Mathews, Consulting Engineer, Thomas Worcester, Inc., Boston, Mass.

Junior: Syed I. Husain, Student, Harvard Graduate School of Engineering, Cambridge, Mass.

Corporate: Board of Water Commissioners, Town of Norfolk, Mass.; Rumford and Mexico Water District, Rumford, Me.

Oliver M. Drummond, of the Greater Boston Speakers' Bureau, gave a talk appealing for support of the coming drive for the Red Cross Fund.

A paper on "Results of Universal Metering at Naugatuck Water Company" was read by William H. Moody, President and General Manager, Naugatuck Water Co., Naugatuck, Conn.

A paper on "The Utilization of Electrical and Radioactivity Methods of Well Logging for Ground-Water Supply Development" was read by John J. Baffa, Consulting Engineer, New York, N. Y.

March 1948 Meeting

Hotel Statler, Boston, Mass.

Thursday, March 18, 1948

President Donald C. Calderwood in the Chair.

Secretary Knox announced the election of the following new members:

Members: Roy O. Leonard, Contractor, Framingham, Mass.; Enrique E. Lilue, Director, Water Supply for Caracas, Venezuela; Julius A. Nido, Superintendent, Water Department, Waterbury, Conn.

Corporate: Leicester Water Supply District, Leicester, Mass.

Upon motion of Harold W. Griswold, duly seconded, it was Voted that this year the Nominating Committee consist of the five latest past-presidents, excluding those on the Executive Committee, that they be Percy A. Shaw, Leland G. Carlton, Francis H. Kingsbury, Horace L. Clark and Karl R. Kennison, and that, as last year, they elect their own chairman.

A paper on "Filter Plant Operation at Cambridge, Massachusetts" was read by Fred E. Smith, Chemist, Water Department, Cambridge, Mass.

A paper on "Waterworks Short-Cuts or Gadgets" was read by Thomas E. Kennedy, Superintendent and Registrar, Water Department, Fitchburg, Mass.

A paper on "Some Highlights on Private Water Company Operation" was read by Allen M. Symonds, Water Utilities Service Corp., Millbury, Mass.

7B.1-T-1947

Tentative

Standard Specifications

for

REINFORCED CONCRETE WATER PIPE—STEEL CYLINDER TYPE, NOT PRESTRESSED

These "Tentative Standard Specifications for Reinforced Concrete Water Pipe—Steel Cylinder Type, Not Prestressed" are based upon the best known experience and are intended for use under normal conditions. They are not designed for unqualified use under all conditions and must be reviewed by the engineer responsible for the construction and modified as necessary to meet specific conditions pertaining to each individual installation.

American Water Works Association

Approved as Tentative by the Board of Directors of the A.W.W.A. on December 11, 1947

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Table of Contents

General—Section 1–1

Scope 1–1.1
Definitions 1–1.2
Essential Requirements 1–1.3
Plans and Data Furnished by Purchaser 1–1.4
Supplementary Details Specified by Purchaser 1–1.5
Data Submitted by Contractor 1–1.6
Marking 1–1.7
Inspection 1–1.8
Material and Workmanship 1–1.9
Tests 1–1.10

Material Specifications—Section 1–2

Cement 1–2.1
Fine Aggregate 1–2.2
Coarse Aggregate 1–2.3
Samples of Concrete Aggregates 1–2.4
Water 1–2.5
Steel for Cylinders 1–2.6
Steel for Reinforcement 1–2.7
Steel for Joint Rings 1–2.8
Steel Castings for Fittings 1–2.9
Steel Plates for Specials and Fittings 1–2.10

Fabrication of Pipe—Section 1–3

General Requirements 1–3.1
Design of Steel Reinforcement 1–3.2
Joint Rings 1–3.3
Gaskets 1–3.4
Fabrication of Steel Cylinders 1–3.5
Fabrication of Reinforcement Cage .. 1–3.6
Concrete for Pipe 1–3.7
Curing of Pipe 1–3.8

Specials and Fittings—Section 1–4

General 1–4.1
Specials (Type A) 1–4.2
Specials (Type B) 1–4.3
Curves, Bends and Closures 1–4.4
Openings and Connections 1–4.5

Tentative Standard Specifications for

Reinforced Concrete Water Pipe—Steel Cylinder Type, Not Prestressed

Section 1–1—General

Sec. 1–1.1—Scope

These specifications cover the manufacture of reinforced concrete water pipe with steel cylinder which is not prestressed and which is designed for static heads ranging from a minimum of 100 ft. to a maximum of 600 ft. The specifications do not include delivery, laying, field testing or sterilization of the pipe.

Sec. 1–1.2—Definitions

In these specifications the following definitions will apply:

1.2.1. *Purchaser.* The word "purchaser" shall mean a person, firm, corporation or governmental subdivision entering into a contract or agreement to purchase any materials, or have any work performed, according to these specifications.

1.2.2. *Contractor.* The word "contractor" shall mean the person, firm or corporation executing the contract or agreement with the purchaser to furnish any materials or perform any work according to these specifications.

1.2.3. *Manufacturer.* The word "manufacturer" shall mean the person, firm or corporation who actually manufactures the pipe, acting either directly as the contractor, or as a subcontractor. If the manufacturer is acting as a subcontractor under the contractor, the obligations of the manufacturer under these specifications shall be considered as obligations of the contractor, and the contractor shall be responsible for their performance.

1.2.4. *Engineer.* The word "engineer" shall mean the engineer employed by the purchaser and acting as his representative; the purchaser himself, acting as his own engineer; and their respective assistants and inspectors.

1.2.5. *A.S.T.M.* The term "A.S.T.M." shall mean the American Society for Testing Materials.

1.2.6. *Approved.* The term "approved" shall mean having received the approval of the engineer.

Sec. 1–1.3—Essential Requirements

The pipe shall have the following principal features: a welded sheet-steel or steel-plate cylinder with steel joint rings welded to its ends; a reinforcing cage, or cages, of steel rods or bars surrounding the steel cylinder; a wall of dense concrete covering the steel cylinder inside and out; a self-centering joint with a preformed gasket of rubber or lead, so designed that the joint will be watertight under all conditions of service.

Sec. 1–1.4—Plans and Data Furnished by Purchaser

It is understood that the purchaser shall furnish to the contractor plans and profiles of the pipeline showing: alignment and grades; the location of all outlets, connections and special ap-

purtenances; the design head or the required cross-sectional area of effective circumferential reinforcement per foot of pipe wall for each portion of the pipeline; and such special details as are necessary for the manufacture of the pipe and fittings in accordance with these specifications and with the specific requirements of the work for which the pipe is made.

Sec. 1–1.5—Supplementary Details Specified by Purchaser

When purchasing pipe under these specifications, it will be necessary for the purchaser to make supplementary statements specifying: the manner of storage and delivery, if these are required of the contractor or manufacturer; the type of specials and fittings to be furnished; and the shell thickness and other special requirements for pipe with a diameter larger than 84 in.

Sec. 1–1.6—Data Submitted by Contractor

1.6.1. Drawings and schedules showing full details of reinforcement, concrete and joints for the straight pipe, specials and connections shall be furnished by the contractor. All drawings and schedules shall be submitted for approval in quadruplicate, and one copy shall be returned to the contractor after approval. No pipe shall be manufactured until the drawings have been approved. The contractor shall be responsible for the accurate detail, fabrication and fitting of the pipe.

1.6.2. If specifically required, drawings and schedules shall include a location profile, with reference to the stationing on the contract drawings. The profile shall show each section of the line where the design head is different; the design head and the station of the beginning and end of the section; and the size of pipe, serial numbers, design head, and the thickness of pipe and area of steel (per linear foot of pipe) in the reinforcing cage and steel cylinder shall be listed for each section of pipeline for which the design head or the equivalent internal pressure fixed by the purchaser is different.

Sec. 1–1.7—Marking

Each special and straight pipe shall have plainly marked, on both the outside and the inside, the head for which it is designed or the area of circumferential steel; the date of manufacture; the minor axis of the reinforcing cage, if elliptical reinforcing is used; and marks of identification sufficient to show the proper location of the pipe or special in the line by reference to the layout drawings and schedules which the contractor is required to furnish under Sec. 1–1.6 of these specifications. All beveled pipe shall be marked with the amount of bevel.

Sec. 1–1.8—Inspection

1.8.1. The purchaser and his representatives shall have access to the work wherever it is in preparation or progress, and the contractor shall provide proper facilities for access and for inspection.

1.8.2. Inspection by the purchaser or his representatives, or failure of the purchaser or his representatives to provide inspection, shall not relieve the contractor of his responsibility to furnish materials and to perform work in accordance with these specifications.

1.8.3. Material, fabricated parts and pipe which are discovered to be defective, or which do not conform to the requirements of these specifications will be subject to rejection at any time

prior to final acceptance of the pipe. Rejected material and pipe shall promptly be removed from the site of the work.

Sec. 1–1.9—Material and Workmanship

All material furnished by the contractor shall be new and of the quality specified. All work shall be done in a thorough, workmanlike manner by mechanics skilled in their various trades.

Sec. 1–1.10—Tests

1.10.1. The contractor shall furnish, in advance of the manufacture of steel cylinders and reinforcing cages, mill-test reports on each heat from which the steel is rolled, if required.

1.10.2. The contractor shall provide test specimens cut on the job from each shipment of steel for reinforcing and for cylinders, as directed by the engineer.

1.10.3. Each completed steel cylinder with joint rings welded to its ends shall be subjected to a hydrostatic test as specified herein under Sec. 1–3.5.4.

1.10.4. Welds in reinforcing rods or bars shall be tested as specified under Sec. 1–3.6.

1.10.5. Frequent samples of the mixed concrete shall be taken for making up compression test cylinders as specified under Sec. 1–3.7.5.

1.10.6. The expense of the required mill tests of materials, and of testing the completed steel cylinders and the welds in reinforcing, shall be borne by the contractor. All other tests shall be made by representatives of the purchaser at the purchaser's expense, except as otherwise specifically provided.

Section 1–2—Material Specifications

Sec. 1–2.1—Cement

2.1.1. Cement for concrete work shall conform to the "Standard Specifications for Type I Portland Cement" (A.S.T.M. Designation C150-44), unless cement with sulfate-resisting qualities is specified. Sampling and testing shall conform to the individual A.S.T.M. specifications designated therein.

2.1.2. Satisfactory facilities shall be provided for identifying, inspecting and sampling cement at the mill, the warehouse and the site of the work. The purchaser shall have the right to inspect the cement and obtain samples for testing at any of these points.

2.1.3. Cement shall be stored in a weather-tight, dry, well-ventilated structure approved by the engineer.

2.1.4. Cement salvaged by cleaning cement sacks, mechanically or otherwise, shall not be used in the work. Cement containing lumps will be rejected and shall immediately be removed from the site of the work.

2.1.5. If the temperature of the cement exceeds 150°F., it shall be stored until cooled to that temperature.

Sec. 1–2.2—Fine Aggregate

2.2.1. Fine aggregate for concrete shall consist of natural sand and shall be the fine granular material resulting from the natural disintegration of rock. It shall consist of clean, hard, durable, uncoated particles. At the time of use it shall be entirely free of frozen material.

2.2.2. Fine aggregate shall be free from organic impurities to the extent that, when subjected to the color test for organic impurities, it shall produce a color in the sodium hydroxide solution not darker than that of Fig. 2 in the "Standard Method of Test for

Organic Impurities in Sands for Concrete" (A.S.T.M. Designation C40-33).

2.2.3. Fine aggregate shall be of such quality that mortar composed of it, when tested by the "Standard Method of Test for Structural Strength of Fine Aggregate Using Constant Water-Cement Ratio Mortar" (A.S.T.M. Designation C87-44), shall have a compressive strength equal to that of similar specimens—of the same proportions and composed of the same cement and Ottawa sand—graded as specified in the "Method of Test for Compressive Strength of Hydraulic-Cement Mortars" (A.S.T.M. Designation C109-44).

TABLE 1

Gradation Requirements for Fine Aggregate

Sieve Size	Total Passing, by Weight *per cent*
⅜ in.	100
No. 4	95–100
No. 8	65–90
No. 16	45–70
No. 30	20–55
No. 50	5–30
No. 100	2–8
No. 200	0–4

2.2.4. Fine aggregate shall be well graded from coarse to fine and, when tested by means of laboratory sieves in accordance with the "Standard Method of Test for Sieve Analysis of Fine and Coarse Aggregates" (A.S.T.M. Designation C136–39), shall conform to the gradation requirements in Table 1.

The gradation requirements given in Table 1 represent the extreme limits for determining the suitability of fine aggregate under these specifications. To maintain uniformity of gradation for aggregate from any given source, a fineness modulus determination shall be made upon representative samples from that source. Thereafter the fineness modulus of all shipments therefrom shall not vary more than ± 0.20 from the fineness modulus of the representative sample.

Sec. 1–2.3—Coarse Aggregate

2.3.1. Coarse aggregate for concrete shall consist of hard, durable particles of crushed stone or crushed or uncrushed gravel conforming to the requirements and tests given in paragraphs 2.3.2 through 2.3.5.

2.3.2. Coarse aggregate shall be well graded from coarse to fine and, when tested by means of laboratory sieves in accordance with the "Standard Method of Test for Sieve Analysis of Fine and Coarse Aggregates" (A.S.T.M. Designation C136-39), the gradation of each designated size shall conform to that shown in Table 2.

TABLE 2

Gradation Requirements for Coarse Aggregate

Sieve Size*	Aggregate Size Designated—*in.*		
	½	¾	1
	Total Passing, by Weight *per cent*		
2 in.			
1½ in.			100
1 in.		100	90–100
¾ in.	100	90–100	
½ in.	90–100		25–60
⅜ in.	40–75	20–55	
No. 4	0–15	0–10	0–10
No. 8	0–5	0–5	

* Square openings.

The designated size or sizes of coarse aggregate used for pipe shall be subject to the approval of the engineer and shall be such that the concrete can readily be placed around the cylinder and reinforcing, to provide solid, compact, homogeneous walls and smooth

surfaces. The designated sizes shall not exceed ½ in. for 36-in. and smaller pipe, ¾ in. for 42- to 60-in. pipe and 1 in. for 66-in. and larger pipe.

2.3.3. Deleterious substances in coarse aggregate shall not exceed the amounts given in Table 3, as determined by sampling and testing procedures listed in the "Standard Specifications for Concrete Aggregates" (A.S.T.M. Designation C33-44).

2.3.4. Thin and elongated pieces, the maximum dimension of which exceeds five times the minimum, shall not be in excess of 10 per cent of the coarse aggregate by weight.

2.3.5. The coarse aggregate, when subjected to five alternations of the sodium sulfate test in accordance with the "Tentative Method of Test for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate" (A.S.T.M. Designation C88-46T), shall have a corrected loss not in excess of 12 per cent.

Sec. 1–2.4—Samples of Concrete Aggregates

At least two weeks prior to mixing concrete, the contractor shall deliver in suitable containers, for preliminary approval, samples of not less than 1 cu.-ft. each of fine aggregate and coarse aggregate. All samples shall be plainly labeled to indicate the source of the material, the date and the name of the collector. Methods of sampling aggregates shall be in accordance with the "Tentative Methods of Sampling Stone, Slag Gravel, Sand and Stone Block for Use as Highway Materials" (A.S.T.M. Designation D75-46T).

Sec. 1–2.5—Water

Water used for concrete and for curing pipe shall be clean and free from oil, acid, strong alkalies or vegetable matter, and the source shall be approved by the engineer.

Sec. 1–2.6—Steel for Cylinders

2.6.1. Steel for cylinders less than ¼ in. thick shall conform to the "Tentative Specifiations for Light Gage Structural Quality Flat Hot-Rolled Carbon Steel, Open-Hearth, Grade B" (A.S.T.M. Designation A245-44T).

2.6.2. Steel for cylinders ¼ in. or more in thickness shall conform to the "Tentative Specifications for Low and Intermediate Tensile Strength Carbon-Steel Plates of Structural Quality, Grade B" (A.S.T.M. Designation A283-46).

TABLE 3

Permissible Amounts of Deleterious Substances in Coarse Aggregate

Material	Maximum Weight Limit *per cent*
Soft particles	4.00
Coal and lignite	0.50
Clay lumps	0.25
Material finer than 200 sieve	1.00
Combined total of above items	5.00

Sec. 1–2.7—Steel for Reinforcement

2.7.1. Rods or bars for reinforcement of concrete shall conform to the "Standard Specifications for Billet-Steel Bars for Concrete Reinforcement, Structural Grade" (A.S.T.M. Designation A15-39). Steel wire for reinforcement of concrete shall conform to the "Standard Specifications for Cold-Drawn Steel Wire for Concrete Reinforcement" (A.S.T.M. Designation A82-34). Wire used for ties may be annealed.

2.7.2. Wire-mesh reinforcement for mortar coating of fittings shall conform to the "Standard Specifications for

Welding Steel Wire Fabric for Concrete Reinforcement" (A.S.T.M. Designation A185-37).

Sec. 1–2.8—Steel for Joint Rings

2.8.1. Steel strips for bell rings less than ¼ in. thick shall conform to the "Tentative Specifications for Light Gage Structural Quality Flat Hot-Rolled Carbon Steel, Open-Hearth Process, Grade A" (A.S.T.M. Designation A245-44T).

2.8.2. Steel plate for bell rings ¼ in. or more in thickness shall conform to the "Tentative Specifications for Low and Intermediate Tensile Strength Carbon-Steel Plates of Structural Quality, Grade A" (A.S.T.M. Designation A283-46T).

2.8.3. Special shapes for spigot joint rings shall conform to the "Standard Specifications for Boiler Rivet Steel and Rivets, Grade A" (A.S.T.M. Designation A31-40) or to the "Tentative Specifications for Low and Intermediate Tensile Strength Carbon-Steel Plates of Structural Quality, Grade A" (A.S.T.M. Designation A283-46T).

Sec. 1–2.9—Steel Castings for Fittings

Steel castings for fittings shall conform to the "Tentative Specifications for Mild- to Medium-Strength Carbon-Steel Castings for General Application, Grade 70–36, Normalized" (A.S.T.M. Designation A27-46T).

Sec. 1–2.10—Steel Plates for Specials and Fittings

Steel plates for specials and fittings shall conform to the "Tentative Specifications for Low and Intermediate Tensile Strength Carbon-Steel Plates of Structural Quality, Grade B" (A.S.T.M. Designation A283-46T).

Section 1–3—Fabrication of Pipe

Sec. 1–3.1—General Requirements

3.1.1. In general, pipe shall have a nominal length of 12, 14 or 16 ft.; except for bends, reducers, closure pieces and other special fittings which may be made in shorter lengths.

3.1.2. Pipe shall be round and true and shall have smooth and dense finished surfaces. The mean internal diameter of any portion of each section of pipe shall not fall short of the nominal diameter or size specified by more than ¼ in., if the pipe is 48 in. or smaller; nor by more than ½ in., if the pipe is 54 in. or larger.

3.1.3. The minimum wall thickness, the minimum thickness of concrete lining and the minimum and maximum center-to-center spacing of circumferential reinforcement for each size of pipe shall be as shown in Table 4.

3.1.4. The rubber gasket type of joint shall be used for 30-in. and smaller pipe, and either the rubber or lead gasket type shall be used for pipe larger than 30 in.

Sec. 1–3.2—Design of Steel Reinforcement

The reinforcement of the pipe shall consist of a welded steel cylinder surrounded by a cage or cages of reinforcement bars. The cylinder shall be not less than 16 gage, U.S. Standard, and shall be of approved thickness. The combined cross-sectional area of steel in the cylinder and in the reinforcement cage shall be such that the steel will not be stressed in excess of 12,500 psi. when the pipe is subjected to an internal pressure equivalent to the hydrostatic head or pressure as

fixed by the purchaser, with no allowance for the tensile strength of the concrete. The cross-sectional area of the circumferential reinforcing bars shall be not less than 40 per cent of the combined area of the steel cylinder and cage reinforcement per linear foot of pipe, unless otherwise specifically permitted. Reinforcement for pipe to be subjected to heavy traffic loads or excessive trench cover shall be in accordance with the special requirements of the purchaser.

either by a resistance welder or by a hand electric-arc weld. After welding, the rings shall be smoothed by grinding the rough surfaces of the weld flush with the adjacent surface. The rings shall be expanded by a press beyond their elastic limits so that they are accurately shaped. They shall be checked for size and shape on accurate templates before being welded to the cylinders. The minimum thickness of the completed bell or spigot rings shall be $\frac{3}{16}$ in. The rings shall conform to the

TABLE 4

Requirements for Pipe of Various Sizes

Pipe id.	Minimum Thickness		Circumferential Reinforcement Spacing	
	Pipe Wall	Concrete Lining	Min.	Max.
	in.			
20	3½	1	1½	4
24	3½	1	1½	4
30	3½	1	1½	4
36	4	1	1½	4
42	4½	1¼	1¾	5
48	5	1¼	1¾	5
54	5½	1¼	1¾	5
60	6	1¼	1¾	5
66	6½	1½	2¼	6
72	7	1½	2¼	6
84	8	1½	2¼	6

Sec. 1–3.3—Joint Rings

The steel bell-and-spigot joint rings for joints of the rubber or lead gasket type shall be so designed and fabricated that when the pipe is laid it will be self-centering. The rings shall be accurately formed and finished to obtain a close, sliding fit for the self-centering surfaces. The tolerance between the theoretical diameters and the actual diameters of the contact surfaces shall not exceed $\frac{1}{32}$ in. Each ring shall be formed by one or more pieces of steel butt-welded together, details submitted by the manufacturer and approved by the engineer. The joint rings for rubber gasket joints shall be so designed that, when the pipe is laid and the joint completed, the gasket will be enclosed on all four sides. The contact surfaces shall be smooth, to prevent cutting of the rubber gasket during installation. The joint rings for lead gasket joints shall be so designed that, when two pipes are joined, there will be a wedge-shaped recess between the bell-and-spigot joint rings to receive the gasket. The portions of

the joint rings which will be exposed after the pipe is cast shall be protected from corrosion by an approved coating.

Sec. 1–3.4—Gaskets

3.4.1. The rubber gasket type of joint shall be sealed with a continuous ring gasket made of a special composition rubber of such size and cross section as to fill completely the recess provided for it. The gasket shall be the sole element depended upon to make the joint watertight and shall have smooth surfaces free from pitting, blisters, porosity and other imperfections. The rubber compound shall contain not less than 65 per cent by volume of first-grade natural crude rubber. The remainder of the compound shall consist of pulverized fillers free from rubber substitutes, reclaimed rubber and deleterious substances. The compound shall meet the following physical requirements when tested in accordance with appropriate sections of "Methods of Physical Tests and Chemical Analyses for Rubber Goods" (Federal Specification ZZ-R-601 and 601A):

Tensile strength. The tensile strength of the compound shall be at least 3,000 psi.

Elongation at rupture. Two-inch gage marks shall stretch to not less than 10 in. at rupture.

Specific gravity. The specific gravity shall be between 1.15 and 1.23.

Cold flow test. The percentage of cold flow—computed as 100 times the change in thickness divided by the original thickness—shall not exceed 12 per cent when tested by subjecting a disk of the material, $\frac{1}{4}$ in. thick by $\frac{3}{4}$ in. in diameter, to a pressure of 600 psi., using a spring pressure device placed in an air oven at a temperature of 158°F. for 24 hours.

Tensile strength after aging. The tensile strength of the compound, after being subjected to an accelerated aging test for 96 hours in air at 158°F., shall not be less than 80 per cent of the tensile strength before aging. The test shall be that described in "Methods for Testing Rubber Goods" (Federal Specification ZZ-R-601-A, Sec. 2, Par. 14).

3.4.2. The lead gasket type of joint shall be sealed with a continuous ring of fiber-filled soft lead gasket, of suitable size and cross section, to be calked from the inside of the pipe into the wedge-shaped recess formed by the joint rings. The lead gasket shall be the sole element depended upon for making the joint watertight.

3.4.3. The contractor shall submit for approval details of the shape and size of the gaskets he proposes to furnish. If required by the engineer, the contractor shall also submit test results showing the chemical and physical properties of the materials used in the manufacture of the gaskets.

Sec. 1–3.5—Fabrication of Steel Cylinders

3.5.1. The cylinders shall be formed by shaping and welding together steel sheets or plates of specified material and thickness. The cylinders shall be accurately shaped to the size required, and the joint rings shall be welded to the ends before testing.

3.5.2. All welding shall be done by the shielded-arc process which excludes the atmosphere during the deposition of the metal. Manual welders shall be qualified in accordance with Par. U-69 of the A.S.M.E. "Code for Unfired Pressure Vessels." The manufacturer shall submit for approval the specific details of materials and methods he proposes to use in welding before any welding is done.

3.5.3. Specimens for tensile and bending tests of welds shall be furnished by the contractor to the engineer as required. The number of cylinders from which test specimens are required to be cut shall not exceed one in every 300 ft. of pipe; provided that if tests indicate the welding is unsatisfactory, the contractor shall furnish additional samples as advised by the engineer. Cylinders from which test specimens have been cut may be patch-welded in an approved manner and used in the work. The test specimens, procedure and results shall conform to the requirements of the "Reduced Section Tensile Test" and the "Free Bend Test" described in Sec. 3–5.1, 3–5.2 and 3–5.3 of "Standard Specifications for Electric Fusion Welded Steel Water Pipe for Sizes 30 Inches and Over" (A.W.W.A. 7A.3–1940). The expense of the welding tests shall be borne by the purchaser.

3.5.4. Each steel cylinder, with joint rings welded to its ends, shall be subjected to a hydrostatic test under a water pressure which stresses the steel to a unit stress of at least 20,000 psi. but not greater than 25,000 psi. While under pressure test, all welds shall be thoroughly inspected and all parts showing leakage shall be marked. Cylinders which show any leakage under test shall be rewelded at the points of leakage and subjected to another hydrostatic test. The finished cylinder, with joint rings attached, shall not be used in the work unless it is completely watertight under the required test pressure.

Sec. 1–3.6—Fabrication of Reinforcement Cage

The steel reinforcement cage or cages shall be made of continuous or welded steel rods wound in helical form, or of individual bars shaped and butt- or lap-welded into circular rings, as specified by the purchaser. Each circumferential weld in the rods or bars shall be subjected to a test stress of 25,000 psi. before being assembled in the cage. The circumferential rods or bars in the cage shall be accurately spaced and shall be rigidly assembled by means of longitudinal rods or wires securely attached to them in an approved manner. Each cage shall be fabricated and rigidly held in such a manner that the reinforcement will remain in proper position during the casting of the pipe. The minimum distance between the reinforcing steel and the surface of the pipe shall be 1 in.

Sec. 1–3.7—Concrete for Pipe

3.7.1. *Proportioning.* The proportions of cement, fine aggregate, coarse aggregate and water used in concrete for pipe shall be subject to and shall not be changed without the approval of the engineer. The proportions shall be determined and controlled as the work proceeds, to obtain homogeneous, dense, workable, durable concrete of specified strength in the walls of the pipe and a minimum of defects in the surfaces of the pipe. The proportions shall be those which will give the best over-all results with the particular materials used for the work and shall be subject to the following limitations:

Cement factor. A minimum of 7.0 bags of cement shall be used for each cubic yard of concrete.

Water-cement ratio. A maximum of 5.8 gal. of water shall be employed per bag of cement.

Ratio of fine aggregate to cement. A minimum of 1.50 and a maximum of 2.00 parts of fine aggregate shall be mixed with 1 part of cement by volume.

Ratio of total aggregates to cement. A minimum of 4.00 and a maximum of 4.50 parts of coarse and fine aggregates shall be mixed with 1 part of cement by volume.

3.7.2. *Measurement of materials.* A barrel of cement shall be considered as 4 cu.ft. or 376 lb., and a bag of cement shall be considered as 1 cu.ft. or 94 lb. Cement in standard sacks need not be weighed, but bulk cement, if its use is permitted, shall be weighed. Water for mixing shall be measured by volume or by weight. Concrete aggregates for each batch shall be measured separately by weighing. The proportions of aggregates shall be computed on the saturated and surface-dry basis and the water-cement ratio shall be exclusive of water within the aggregates and absorbed by them. The equivalent unit weights for both fine and coarse aggregates shall be determined in accordance with the "Standard Method of Test for Unit Weight of Aggregate" (A.S.T.M. C29-42), using a 1-cu.ft. cylindrical container. The equipment and devices for weighing and measuring shall at all times be accurate within 1 per cent.

3.7.3. *Mixing.* The mixing shall be thoroughly done by a batch mixer of approved type, rotating at a speed of 14–20 rpm. or a peripheral speed of approximately 200 fpm. The drum shall be entirely emptied before recharging. Mixing time shall be at least two minutes. Transit mixing shall not be used except by written authorization and under specific requirement of the engineer.

3.7.4. *Strength.* Standard concrete cylinders shall attain a compressive strength of not less than 2,300 psi. in 7 days and 4,000 psi. in 28 days, as determined by tests of cylinders taken from each day's pour. Pipe made from concrete which does not meet the strength tests will be subject to rejection.

3.7.5. *Samples and testing.* At least four standard test cylinders shall be prepared from each day's pour of concrete by the engineer. Test cylinder specimens shall be made and stored in conformance with the "Standard Method of Making and Curing Concrete Compression and Flexure Test Specimens in the Field" (A.S.T.M. Designation C31-44). The specimens shall be tested at the expense of the purchaser by an approved testing laboratory.

3.7.6. *Forms.* The forms shall be of steel made with butt joints throughout and with the interior surface smooth and true. The forms shall be so constructed that the inner and outer forms, joint rings and reinforcement shall be held in circular and concentric positions; and so designed that the inside form can be collapsed and the outside form expanded to allow both to be readily removed from the pipe and the base casting ring without injury to the freshly set concrete. Forms shall be sufficiently tight to prevent leakage of mortar; and they shall be stiff enough and so braced as to withstand, without deformation of any kind, all operations incident to the pouring and setting of the concrete. Forms shall be cleaned and oiled before each period of use.

3.7.7. *Placing concrete.* The transporting and placing of concrete shall be carried out by approved methods which will prevent the separation of concrete materials, the displacement of steel from its proper position in the forms and the distortion of the forms. Approved methods of vibrating or rod-

ding shall be used to compact the concrete in the forms and to secure satisfactory surfaces on the pipe. The tops of the pipes shall be kept covered and moist until the forms are removed. Forms shall not be removed until the concrete has set sufficiently to avoid spalling or damage to the pipe during the process of form removal.

Sec. 1–3.8—Curing of Pipe

3.8.1. *General.* The pipe may be cured by water spraying, by steam or by a combination of these methods. Water curing may be used if the temperature is continuously above 50°F. Adequate facilities and space shall be provided for proper curing.

3.8.2. *Water curing.* The pipe shall be kept continually moist by spraying it for a period of at least ten days after it is poured. Satisfactory arrangements for covering the pipe and respraying it shall be provided so that it will not dry out, either on the inside or outside, during the curing period.

3.8.3. *Steam curing.* The pipe, under covering, shall be steam cured on the base rings in a vertical position for a period of at least twelve hours before the forms are removed. Immediately after the forms are removed, the pipe shall be placed under cover for additional steam curing before tipping from the base casting rings. It shall not be so tipped for at least 36 hours after casting and shall be steam cured continuously during this period, except when the forms are being removed. The temperature of the steam within the forms and under the covering shall be at least 110° and not more than 150°F. and the atmosphere shall be sufficiently humid to keep the pipe moist at all times. After the pipe has been tipped and removed to storage, it shall be kept moist for a period of at least seven days. In lieu of the final sprinkling period, the contractor may substitute steam curing for an additional period approved by the engineer, as determined by tests on standard test cylinders cured by a combination of steam and water and by steam alone.

Section 1–4—Specials and Fittings

Sec. 1–4.1—General

The manufacturer shall furnish all fittings and special pieces required for closures, curves, bends, branches, manholes, air valves, blowoffs and connections to main-line valves and other pipes shown on the contract drawings or ordered by the purchaser. Specials shall conform to the details furnished by the purchaser, or—if required—to the details furnished by the manufacturer and approved by the purchaser. Either of two types shall be used:

Type A—specials of the same general type of construction as the straight pipe, with steel-sheet cylinder, concrete lining and reinforced concrete exterior covering;

Type B—specials of cut and welded steel plate of approved thickness, with mortar coating on interior and exterior.

Sec. 1–4.2—Specials (Type A)

The steel sheet shall be cut, shaped and welded to form the properly shaped bend, tee, reducer or other special. The welds shall be inspected and the completed cylinder shall be tested for tightness by an approved method, if specifically required by the purchaser.

A cage or cages of steel reinforcement with approved cross-sectional areas shall be formed around the cylinder and openings. Longitudinal reinforcement sufficient for the additional stresses in the pipe walls shall be provided. The interior concrete shall be placed in a manner similar to that used for straight pipe. The exterior concrete shall be applied in the form of mortar coating placed by an approved method of pressure application.

Sec. 1–4.3—Specials (Type B)

4.3.1. The steel plate for the fabricated steel-plate specials shall be cut, shaped and welded so that the finished special shall have the required shape and interior dimensions. The deflection angle between adjacent courses of a bend shall be not greater than 22½ deg. Adjacent courses shall be joined by butt-welding. The minimum length of the courses shall be one-half the diameter of the pipe. Fabrication and welding shall conform to the requirements of Sec. 1–3.5 of these specifications.

4.3.2. Wire-mesh reinforcing shall be applied to the interior and exterior surfaces of the fabricated special. It shall be 2 × 4-in. No. 13 gage welded wire fabric, held ⅜ in. from the surfaces of the steel plate. The members on the 2-in. spacing shall extend circumferentially around the special with ends overlapped 4 in. and tied together. Longitudinal splices shall be staggered.

4.3.3. The steel plate specials shall be lined and coated with mortar at least ¾ in. thick, deposited on the surfaces under impact produced by revolving brushes, air pressure or other approved means. The mortar shall contain not less than 1 part cement to 4 parts sand of a grading approved for the method of application used and shall develop a 28-day compressive strength of not less than 3,500 psi.

4.3.4. The mortar-coated specials shall be cured either by water spraying or by steam as specified under Sec. 1–3.8 herein.

Sec. 1–4.4—Curves, Bends and Closures

Horizontal and vertical long-radius curves shall be formed by straight pipe in which spigot rings are placed on a bevel. The total angular deflection for beveled pipe shall not exceed 5 deg. at any joint. Slight deflections may be made with straight pipe, provided that the maximum joint opening caused by such deflections shall not exceed 1 in. Short-radius curves and closures shall be formed by fabricated specials of either of the two types specified above.

Sec. 1–4.5—Openings and Connections

Manholes and flanged, spigot or bell connections for air valves, blowoffs or connections to other pipes shall be built into the walls of the concrete pipe at locations shown on the contract drawings or ordered by the purchaser. Wall openings shall be formed by welding fittings of cast steel or fabricated structural steel of approved design to the steel cylinder and the reinforcing cage of straight pipe. If required, the interior and exterior surfaces of structural steel connections shall be lined and coated with reinforced mortar as specified in Sec. 1–4.3 of these specifications.

INDEX OF ADVERTISERS

	Page
Atlas Mineral Products Co.	xxvi
Badger Meter Mfg. Co.	Following front cover
Bailey, Howard E.	ii
Barrett Division, The (Allied Chemical & Dye Corp.)	Following front cover
Barrows, H. K.	ii
Boston Edison Co.	xv
Builders-Providence, Inc. Division of Builders Iron Foundry	xii
Camp, Thomas R.	ii
Cast Iron Pipe Research Assn.	xxxi
Cement Lined Pipe Co.	iii
Centriline Corporation	Following front cover
Eddy Valve Co.	xix
Edson Corp., The	xxi
Eureka Pipe Co., Inc.	xxvi
Fairbanks-Morse Co.	xi
Fay, Spofford & Thorndike	ii
Flexible Sewer Rod Equipment Co.	xxii
Ford Meter Box Co.	xvi
Haley & Ward	ii
Hays Mfg. Co.	xvii
Hersey Mfg. Co.	iv
Hughes, Edward F., Co.	iii
Hydraulic Development Corp.	x
Johns-Manville	Following front cover
Kennedy Valve Mfg. Co.	xiii
Knowles, Morris, Inc.	ii
Koppers Company, Inc.	Following front cover
Layne-New York Co., Inc.	iii
Leadite Co.	Back cover
Leggette, R. M.	ii
Lock Joint Pipe Co.	Facing front cover
Maher, D. L., Co.	iii
Metcalf & Eddy	ii
Morris Machine Works	xviii
National Lead Co. of Mass.	xv
National Water Main Cleaning Co.	viii
Neptune Meter Co.	vii
Omega Machine Co. (Division of Builders Iron Foundry)	v
Pierce-Perry Co.	iii
Pipe Founders Sales Corp.	xxii
Pirnie, Malcolm	iii
Pitometer Co.	iii
Pittsburgh Equitable Meter Co.	Following front cover
Potts, Clyde	ii
Preload Corp.	Following front cover
% Proportioneers, Inc. %	Following front cover
Red Hed Mfg. Co.	xxiv
Rensselaer Valve Co.	ix
Reppucci, C. & Sons, Inc.	iii
Ross Valve Mfg. Co.	xxiii
Smith Mfg. Co., The A. P.	Following front cover
Turbine Equipment Co.	xiv
U. S. Pipe and Foundry Co.	xxxii
Utilities Supply	xxii
Wallace & Tiernan	xx
Warren Foundry and Pipe Corp.	xxi
Welsbach Corporation	xxv
Weston & Sampson	iii
Whitman & Howard	iii
Wood, R. D., Co.	Following front cover
Worthington Pump and Machinery Corp.	vi

(Classified index on page xxix)

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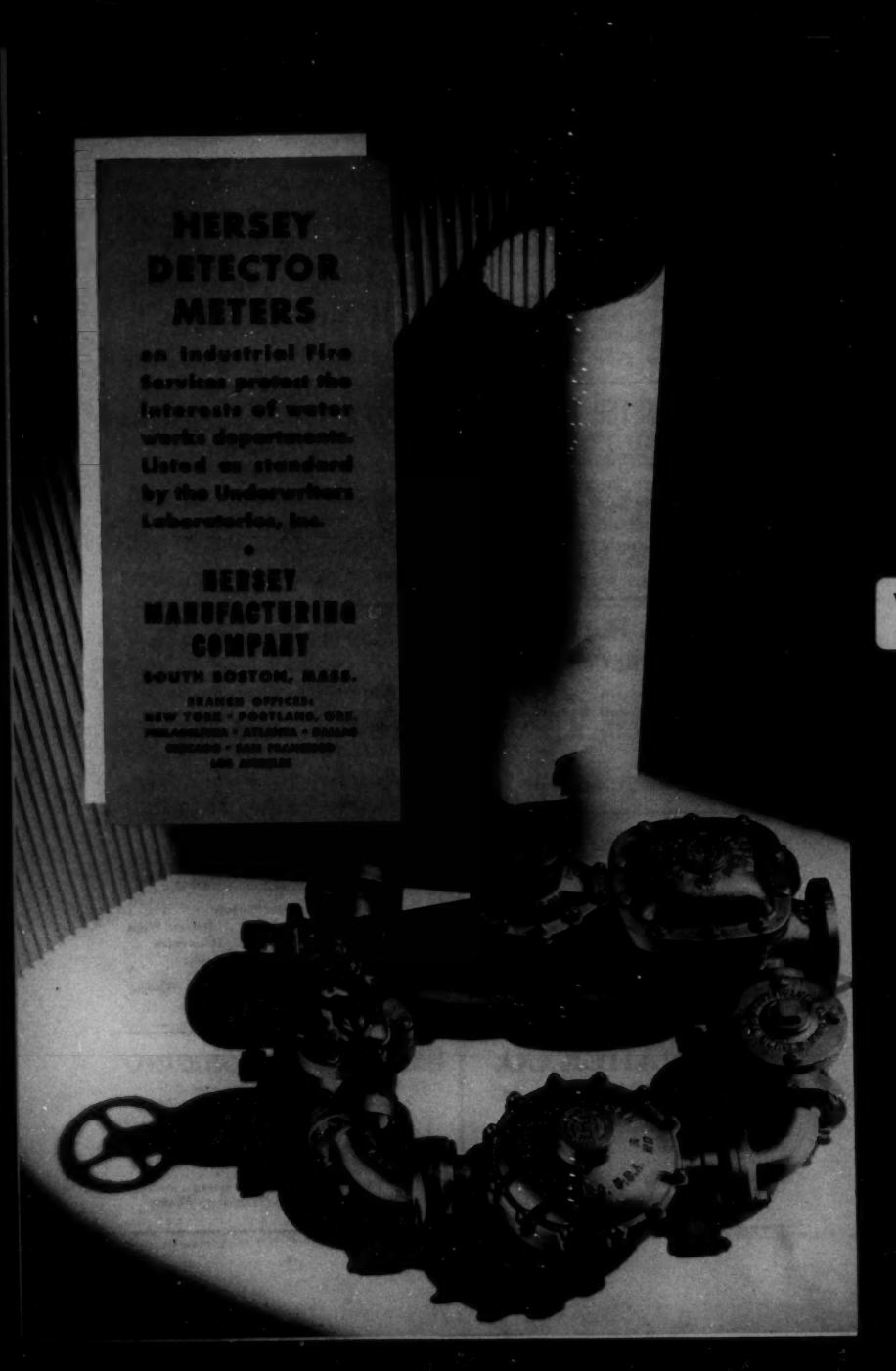
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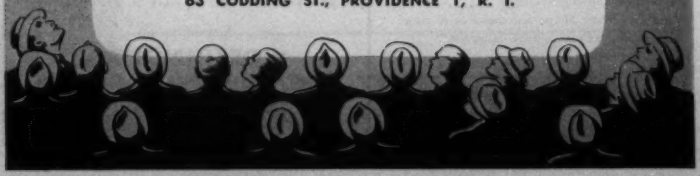

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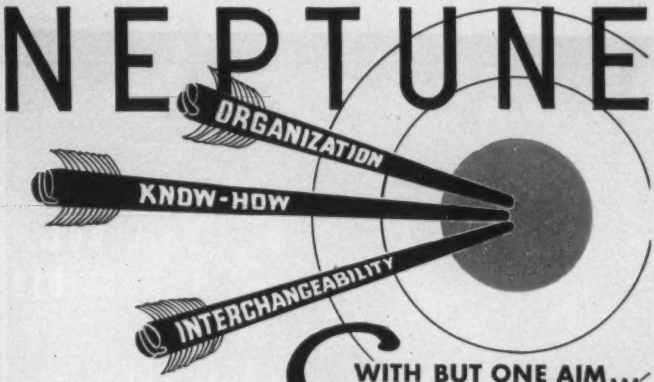

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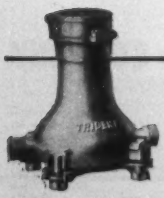

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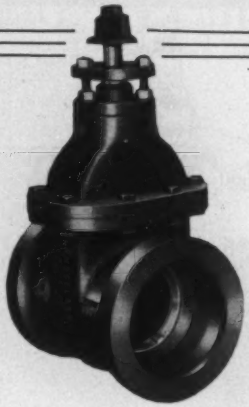

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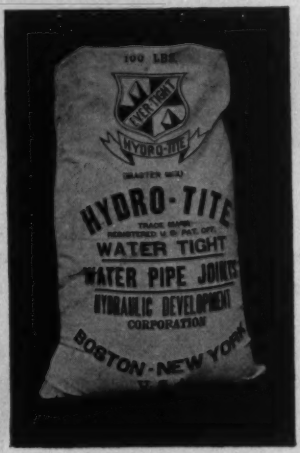

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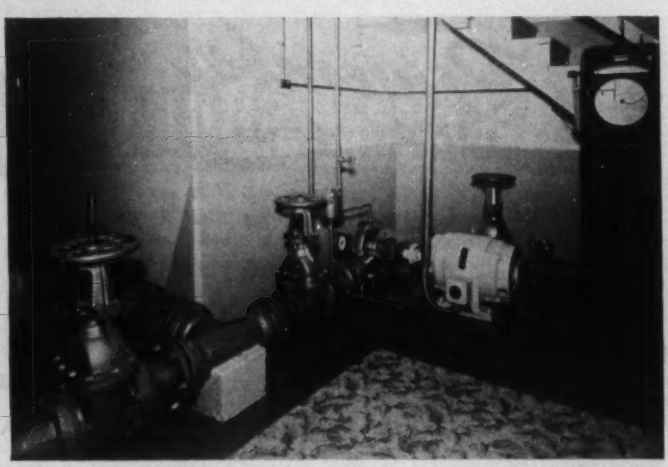

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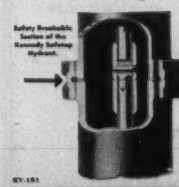

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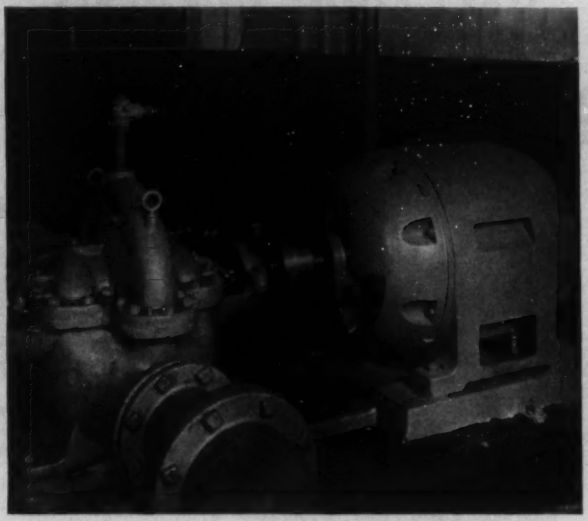

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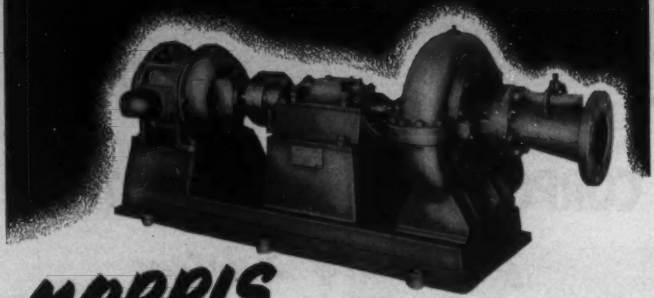

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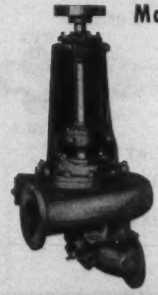

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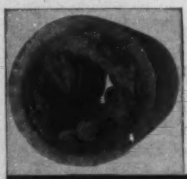

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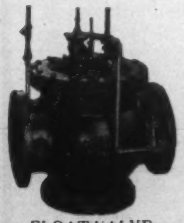

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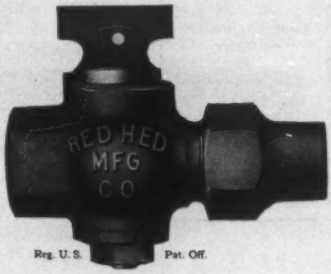

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CLASSIFIED DIRECTORY OF ADVERTISEMENTS

AIR COMPRESSORS.
Edson Corp., The xxi

ASBESTOS CEMENT PIPE.
Johns-Manville Corp. ..... Following front cover

BRASS GOODS.
Eureka Cement Lined Pipe Co. xxvi
Hays Mfg. Co. xvii
Pierce-Perry Co. iii
Red Hed Mfg. Co. xxiv
Smith Mfg. Co., The A. P. ..... Following front cover

CALKING MACHINERY AND TOOLS.
Hydraulic Development Corp. x

CAST IRON PIPE. (See Pipe, Cast Iron.)

CEMENT LINED PIPE. (See Pipe, Cement Lined.)

CHEMICAL FEED APPARATUS.
Builders-Providence, Inc. (Divn. of Builders Iron Fdry.) xii
Omega Machine Co. v
% Proportioneers, Inc. % ..... Following front cover
Wallace & Tiernan Co., Inc. xx

CHLORINATORS.
Builders-Providence, Inc. (Divn. of Builders Iron Fdry.) xii
% Proportioneers, Inc. % ..... Following front cover
Wallace & Tiernan Co., Inc. xx

CLEANING WATER MAINS.
Flexible Underground Pipe Cleaning Co. xxii
National Water Main Cleaning Co. viii

COCKS, CURBS AND CORPORATIONS.
Eureka Cement Lined Pipe Co. xxvi
Hays Mfg. Co. xvii
Pierce-Perry Co. iii
Smith Mfg. Co., The A. P. ..... Following front cover

CONCRETE PIPE. (See Pipe, Concrete.)

CONSTRUCTION AIR TOOLS.
Edson Corp., The xxi

CONTRACTORS' EQUIPMENT.
Hydraulic Development Corp. x

CONTRACTORS.
Layne-New York Co. iii
Maher, D. L. Co. iii
Reppucci, C. & Sons iii

COUPLINGS, FLEXIBLE PIPE.
Johns-Manville Corp. ..... Following front cover

CURB BOXES.
Eureka Cement Lined Pipe Co. xxvi
Hays Mfg. Co. xvii
Pierce-Perry Co. iii

DIAPHRAGMS, PUMPS.
Edson Corp., The xxi
% Proportioneers, Inc. % ..... Following front cover

ENGINEERS.
Bailey, Howard E. ii
Barrows, H. K. ii
Camp, Dresser and McKee ii
Fay, Spofford and Thorndike ii
Haley and Ward ii
Knowles, Morris, Inc. ii
Metcalf and Eddy ii
Pirnie Engineers, Malcolm iii
Potts, Clyde ii
Weston and Sampson iii
Whitman and Howard iii

CLASSIFIED DIRECTORY OF ADVERTISEMENTS *(Continued)*

ENGINES. (See Pumps and Pumping Engines.)

EQUIPMENT. (See Contractors' Equipment.)

FEED WATER FILTERS.
% Proportioneers, Inc. % ..... Following front cover
Ross Valve Mfg. Co., Inc. xxiii

FILTRATION PLANT EQUIPMENT.
Builders-Providence, Inc. (Divn. of Builders Iron Fdry.) xii
% Proportioneers, Inc. % ..... Following front cover

FLAP VALVES.
Eddy Valve Co xix

FLEXIBLE JOINTS.
U. S. Pipe and Foundry Co. xxxii

FURNACES.
Hydraulic Development Corp. x
Leadite Co. ..... Back cover

GATE VALVES. (See Valves.)

HOSE, SUCTION AND CONDUCTION.
Edson Corp., The xxi

HYDRANTS, FIRE.
Eddy Valve Co. xix
Kennedy Valve Mfg. Co. xiii
Rensselaer Valve Co. ix
Smith Mfg. Co., The A. P. ..... Following front cover
Wood, R. D., Co. ..... Following front cover

HYDRANTS, PUMPS.
Edson Corp., The xxi

LEAD.
National Lead Co. of Mass. xv

LEAD PIPE. (See Pipe, Lead.)

LEAD WOOL.
National Lead Co. of Mass. xv

LEAK FINDERS.
Edson Corp., The xxi

METERS, OIL AND WATER.
Badger Meter Mfg. Co. ..... Following front cover
Builders-Providence, Inc. (Divn. of Builders Iron Fdry.) xii
Hersey Mfg. Co. iv
Neptune Meter Co. vii
Pipe Founders Sales Corp. xxii
Pittsburgh Equitable Meter Divn. ..... Following front cover
Worthington-Gamon Meter Co. vi

METER COUPLINGS.
Badger Meter Mgf. Co. ..... Following front cover
Ford Meter Co. xvi
Hays Mfg. Co. xvii
Hersey Mfg. Co. iv
Neptune Meter Co. vii
Red Hed Mfg. Co. xxiv
Smith Mfg. Co., The A. P. ..... Following front cover
Worthington-Gamon Meter Co. vi

METERS (Venturi Type.)
Builders-Providence, Inc. (Divn. of Builders Iron Fdry.) xii

METER BOXES.
Ford Meter Co. xvi

CLASSIFIED DIRECTORY OF ADVERTISEMENTS *(Continued)*

METER TESTERS.
Badger Meter Mfg. Co. ..... Following front cover
Ford Meter Co. xvi
Neptune Meter Co. vii

OIL ENGINES.
Edson Corp., The xxi
Fairbanks, Morse Co. xi

PIPE, ASBESTOS CEMENT.
Johns-Manville Corp. ..... Following front cover

PIPE, BRASS.
Pierce-Perry Co. iii

PIPE, CAST IRON (and Fittings.)
Builders-Providence, Inc. (Divn. of Builders Iron Fdry.) xii
Cast Iron Pipe Research Association xxxi
Pipe Founders Sales Corp. xxii
U. S. Cast Iron Pipe and Foundry Co. xxxii
Warren Foundry and Pipe Co. xxi
Wood, R. D. Co. ..... Following front cover

PIPE, CEMENT LINED.
Cast Iron Pipe Research Association xxxi
Cement Lined Pipe Co. iii
Eureka Cement Lined Pipe Co. xxvi
Pipe Founders Sales Corp. xxii
U. S. Pipe and Foundry Co. xxxii

PIPE, COATING AND LININGS.
Barrett Division ..... Following front cover
Centriline Corp. ..... Following front cover
Koppers Company, Inc. ..... Following front cover

PIPE, CONCRETE.
Lock Joint Pipe Co. ..... Facing front cover

PIPE CUTTING MACHINES.
Smith Mfg. Co., The A. P. ..... Following front cover

PIPE JOINTING MATERIAL.
Atlas Mineral Products Co. xxvi
Hydraulic Development Corp. x
Leadite Co., The ..... Back cover
National Lead Co. of Mass. xv

PIPE, LEAD.
National Lead Co. of Mass. xv
Pierce-Perry Co. iii
Red Hed Mfg. Co. xxiv

PIPE LINING.
Centriline Corp. ..... Following front cover
Preload Enterprises, Inc. ..... Following front cover

PIPE, PRESTRESSED CONCRETE.
Lock Joint Pipe Co. ..... Facing front cover
Preload Enterprises, Inc. ..... Following front cover

PIPE, WROUGHT IRON AND STEEL.
Pierce-Perry Co. iii

PLUG VALVES.
Eddy Valve Co xix
Hays Mfg. Co. xvii
Pittsburgh Equitable Meter Divn. ..... Following front cover

PITOMETERS.
Pitometer Co., Engrs. iii

PORTABLE AIR COMPRESSORS. (See Air Compressors.)

PRESSURE REGULATORS.
Pittsburgh Equitable Meter Divn. ..... Following front cover
Ross Valve Mfg. Co., Inc. xxiii

PROVERS, WATER.
Badger Meter Mfg. Co. ..... Following front cover

CLASSIFIED DIRECTORY OF ADVERTISEMENTS *(Continued)*

PUMPS AND PUMPING MACHINES.
Edson Corp., The ... xxi
Fairbanks, Morse and Co. ... xi
Layne-New York Co., Inc. ... iii
Maher Co., D. L. ... iii
Morris Machine Works ... xviii
Ross Valve Mfg. Co., Inc. ... xxiii
Turbine Equipment Co. ... xiv

RATE CONTROLLERS AND GAUGES.
Badger Meter Mfg. Co. ... Following front cover
Builders-Providence, Inc. (Divn. of Builders Iron Fdry.) ... xii

SHEAR GATES.
Eddy Valve Co ... xix

SLEEVES AND VALVE TAPPINGS.
Eddy Valve Co ... xix
Rensselaer Valve Co. ... ix
Smith Mfg. Co., The A. P. ... Following front cover

SUPPLIES AND TOOLS.
Hydraulic Development Corp. ... x
Leadite Co., The ... Back cover
Pierce-Perry Co. ... iii

TANKS, WATER, FUEL, SLUDGE DIGESTION.
Preload Enterprises, Inc. ... Following front cover

TAPPING MACHINES.
Hays Mfg. Co. ... xvii
Red Hed Mfg. Co. ... xxiv
Smith Mfg. Co., The A. P. ... Following front cover

TAPPING SLEEVES. (See Sleeves and Valves, Tapping.)

VALVE BOXES.
Eddy Valve Co ... xix
Kennedy Valve Mfg. Co. ... xiii
Pierce-Perry Co. ... iii
Pipe Founders Sales Corp. ... xxii
Smith Mfg. Co., The A. P. ... Following front cover
Wood, R. D. Co. ... Following front cover

VALVE INSERTING MACHINES.
Smith Mfg. Co., The A. P. ... Following front cover

VALVES, CHLORINE.
Wallace and Tiernan Co., Inc. ... xx

VALVES, GATE.
Eddy Valve Co ... xix
Kennedy Valve Mfg. Co. ... xiii
Pierce-Perry Co. ... iii
Rensselaer Valve Co. ... ix
Smith Mfg. Co., The A. P. ... Following front cover
Wood, R. D. Co. ... Following front cover

VALVES, REGULATING.
Ross Valve Mfg. Co., Inc. ... xiv

WATER WASTE DETECTION.
Pitometer Co., The ... iii

WELL CONNECTIONS.
Red Hed Mfg. Co ... xxiv

WELLS, GRAVEL, FILTER AND DRIVEN.
Maher Co., The D. L. ... iii

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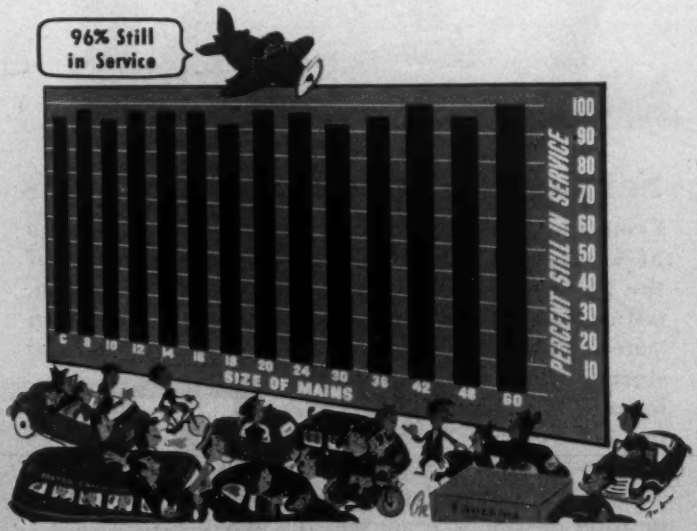

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